Laboratory and Projects Workshop in Chemical Engineering Degree Program in Mexico

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The Korean Conference on Education 2024
Official Conference Proceedings

Abstract
A diagnostic study of the subject Laboratory and Projects Workshop (LPW) of the degree in Chemical Engineering taught at the Faculty of Highest Studies - Zaragoza of the National Autonomous University of Mexico is presented, based on the perception of the professors, the graduated students and the companies that hire them, to realize the applicability of the contents of the subject by comparing them with the professional skills required by the labor market in the chemical industry, to support a proposal to update the subject in the different semesters, until completing the LPW of 9th level within a company. The research was carried out with a mixed approach and with a projective research model. To collect the data and integrate the information of this job, three instruments and an interview guide were developed and submitted to validation by expert judgment, these being mixed for each focus group (professors with 10 years of experience, graduates with a maximum of 5 years of having completed the curriculum, companies that hire chemical engineers and a quality assurance manager). Likert scales with confidence levels from 0.77 to 0.935 were used for the surveys.

Keywords: Chemical Engineering, Competencies, Contents, Labor Market

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Introduction

The present paper is a research whose objective is the development of a diagnosis that contributes to obtain the perception of the graduates, professors and companies that hire Chemical Engineers graduated from the Faculty of Highest Studies - Zaragoza of the National Autonomous University of Mexico (UNAM), about the applicability of the contents of the subject Laboratory and Projects Workshop (LPW) in the labor market and its congruence with the competencies needed by the chemical industry. The four reasons on which this paper focuses are:

1. To confirm the applicability of the contents of the LPW subjects in the labor market.
2. To identify the congruence of the contents of the LPW subjects with respect to the competencies required in the labor market based on the perception of the professors.
3. To identify the competencies that graduates of Chemical Engineering at FES-Zaragoza should have, based on the perception of the companies that hire them.
4. Identify the competencies needed by the chemical industry through the labor market, to compare them with the contents of the LPW subjects.

The approach used in this work is mixed, supported from within the institution with the perception of the professors that has taught or teaches the LPW subject and has at least 10 years of experience, in addition to the external support of the institution that was obtained from the perception of graduates with a maximum of 5 years of having graduated from the degree, as well as from companies that hire Chemical Engineers graduated in FES-Zaragoza.

To collect the data used to integrate the information of this paper, three instruments and an interview guide were prepared and submitted for validation by expert judgment, these being mixed for each focus group (professors with 10 years of experience, graduates with a maximum of 5 years of having completed their studies, companies that hire chemical engineers and a Quality Control Manager who agreed to be interviewed).

The problem is presented and includes a general context, as well as the main indicators that support the importance of the Chemical Engineering degree at national and international level, integrating the problem statement, the formulation of the problem, the research questions, the objectives, and the justification. The main theoretical-conceptual references are identified, where a general description of the research carried out on the subject in general and for the Chemical Engineering degree at FES-Zaragoza is recovered. A clear example of improvement is also included, as well as the conceptual framework linked to the construct of professional competencies, the requirements requested by employers and general aspects of the curricular design in relation to Chemical Engineering. Then the methodological framework is described, which is composed of the research approach, the type of research, the research design, the description of the population and sample. The data collection techniques, a description of the instruments developed for this work, the validation process by expert judgment and a general description of the project phases are presented. Later are presented the results obtained in the research on the perception of graduates and professors of Chemical Engineering at FES-Zaragoza, as well as the additional opinions expressed by both focus groups.

The perceptions of employers who hire Chemical Engineers trained at FES-Zaragoza and the interview with the Quality Control Manager of WYN de México are also presented. Finally, we close with the perception of Chemical Engineering specialists in the world.

Chemical Engineering is a specialty of engineering that deals with the operation and design of chemical plants and methods to improve production. Chemical Engineering develops processes to convert raw materials into useful products, using principles of chemistry, physics, mathematics, biology and economics to efficiently design, use, produce, transport and transform energy and materials (NASEM, 2022).

Chemical Engineering involves from the study of nanotechnology and nanomaterials in the laboratory, to industrial processes that transform raw materials, chemicals, microorganisms, and energy into useful products for society, from the stage of design, modeling, control, and reaction, to the operation of the plant.

Within the Mexican Republic, UNAM is positioned as the best institution at national level that teaches this profession, occupying the 3rd position in Latin America. The QS World University Rankings research published that the Chemical Engineering degree at UNAM is ranked 60th worldwide (Gaceta UNAM, 2023, March 27th).

Chemical engineers develop and design chemical manufacturing processes and apply the principles of chemistry, physics, and mathematics to solve problems involving the production or use of chemicals, fuel, drugs, food, and many other products (AIChE, 2022). Chemical engineers work in different types of industries such as design and construction of process equipment, petrochemicals, food, specialty chemicals, polymers, pulp and paper, pharmaceuticals, biotechnology, microelectronics, among others, such as environmental safety.

Within these industries, chemical engineers rely on their knowledge of mathematics and science, particularly chemistry, to overcome technical problems safely and economically. And they apply their engineering knowledge to solve any technical challenges they encounter, including supporting areas of law, education, publishing, finance, and medicine and in fields requiring technical training.

Chemical engineering is not static and is constantly changing, as shown in Figure 1, which shows the trends and products that are currently driving the chemical industry. Where Industry 4.0 refers to the digital transformation of production processes of related companies and value creation processes.

Based on the assessment of the Deloitte firm (2019), the chemical industry is moving from the Industry 4.0 concept to the fourth industrial revolution where technology leads the changes in companies, as shown in Figure 2.

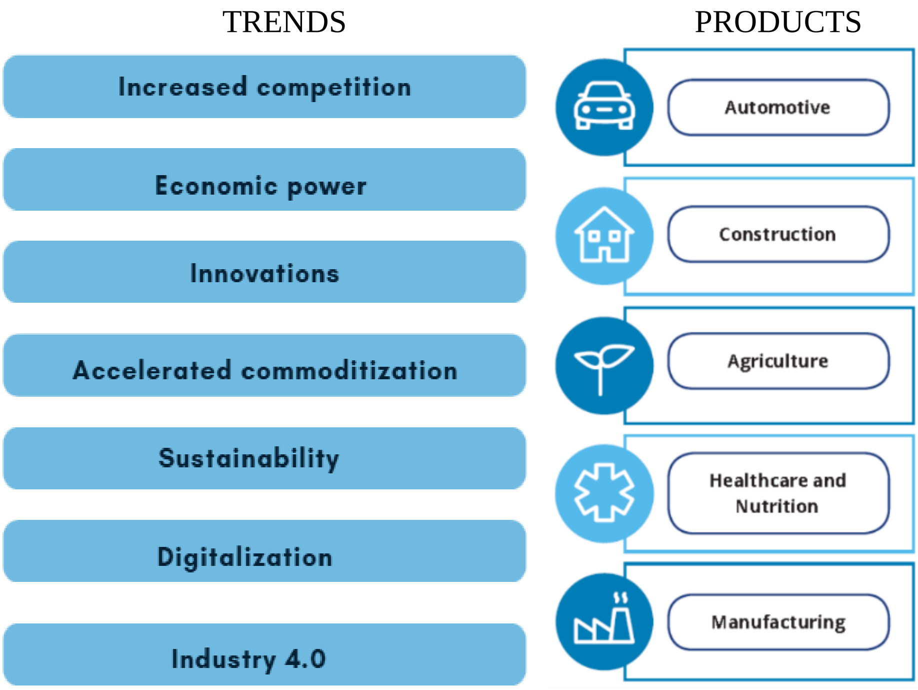

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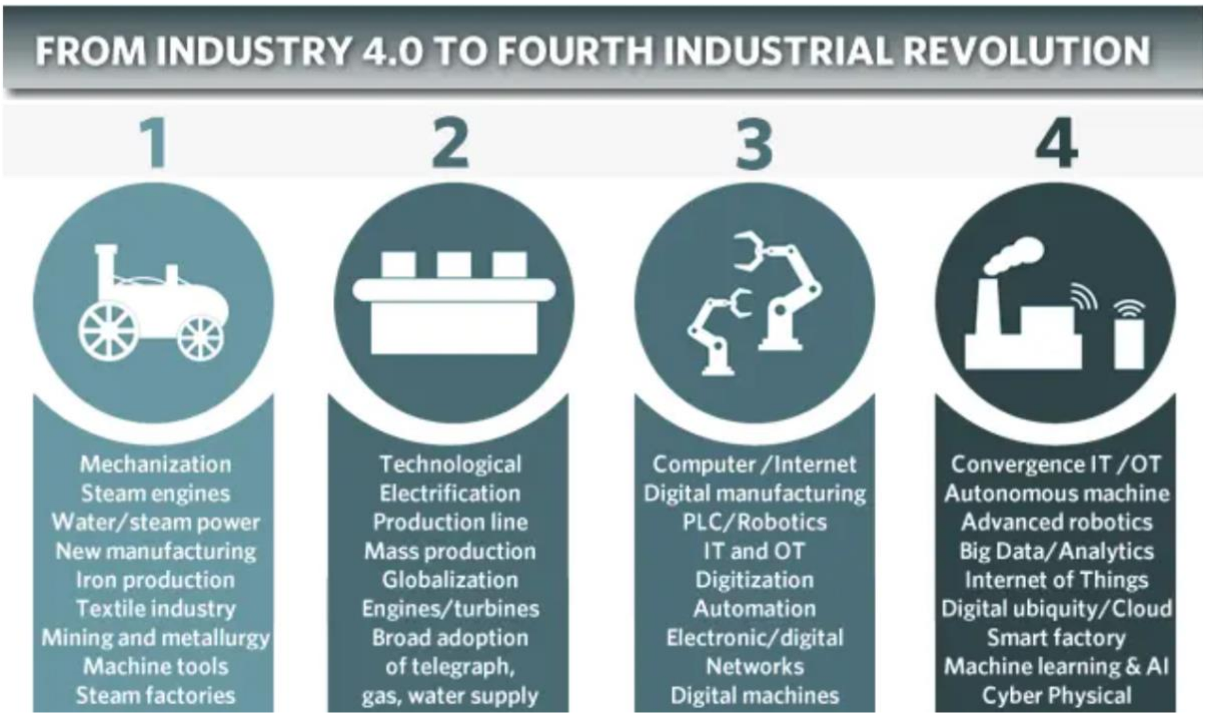
Figure 1: Chemical Industry Trends and Products



https://www.i-scoop.eu/industry-4-0/

Figure 2: The Chemical Industry From Industry 4.0 to the 4th Industrial Revolution

In several research studies it is recognized that, after a century of development, Chemical Engineering is a complete discipline that has made contributions to the economy, particularly by the growth of petrochemicals, but also states that it is necessary to reexamine and improve education in Chemical Engineering because the economic environment is changing rapidly and the industry is booming towards microelectronics, bioengineering and nanotechnology, which forced to review the curricula in Europe, the United States, Asia and the Pacific (Feijoo et al., 2018; Martín et al., 2019; Obiuto et al., 2024), Chemical Engineering will be focused on solving environmental problems in the near future, supporting its decisions in the knowledge of the properties of mass, heat and momentum transfer and their combination with unit operations for the achievement of processes.

Based on the research of *The National Academies of Science, Engineering and Medicine* (*NASEM*, 2022), in its book *New directions for chemical engineering* it can be assured that Chemical Engineering is changing according to the rapid advances in science and technology, such as computer simulation, machine learning and artificial intelligence. It is also known that academic research is migrating from process research to scientific, basic, and applied research. In the same book, the National Academy of Sciences, Engineering and Medicine (NASEM, 2022) mentions that academic institutions have adapted to change and, to achieve this, have focused on three important social responsibilities: education, research and service, the fulfillment of which has brought great benefits to society.

In the field of education, the study and analysis of the core undergraduate curriculum in Chemical Engineering must evolve with the incorporation of new topics that reflect emerging areas of impact and relevant practice, as well as an ongoing dialogue about the very nature of the profession, so the undergraduate curriculum must show resilience of the discipline in the face of change (NASEM, 2022). The curriculum should reflect its basic nature and how it brings together the underlying sciences (chemistry, physics, mathematics, biochemistry, and biology) in an interdisciplinary problem-solving context. It is striking that neither biochemistry nor biology is included in the undergraduate chemical engineering curriculum at FES - Zaragoza.

The Chemical Engineering curriculum should aim at transmitting the fundamental knowledge to translate it into solutions of mass and energy balances, mass and energy transport, chemical kinetics and process design and control, putting it into practice in a laboratory. Without forgetting that the examples used to transmit the knowledge and apply it in practice have changed, and will continue to do so, every time Chemical Engineering finds new applications.

Literature Review

The Chemical Engineering curriculum at the undergraduate level in the United States has a problem-solving approach to mastering the dynamics and thermodynamics of physical and chemical processes, moving through the biochemical and electrochemical realm, and currently has a focus on the photochemical realm. The core curriculum as taught in the United States of America represents a research method and problem-solving toolbox (NASEM, 2022), and, in the perception of a selected group of graduate students and postdocs, is that process science has proven to be comprehensive and adaptable enough to persist for the next 25 years and beyond. However, the profession and its undergraduate curriculum do not always succeed in setting the stage required to attract and retain people with backgrounds and interests that future challenges will demand, so as the Chemical Engineering curriculum evolves, it will need to convey with greater purpose and success, how no profession unleashes the spirit of innovation like engineering and how few disciplines have such a direct and positive effect on people's daily lives.

It is clear that the undergraduate curriculum in Chemical Engineering has been adapting to the needs of industry and society, so the emphasis on new fields of research has created the appearance of a fragmented profession, but we must remember that the curriculum has endured, not because it is frozen, but because it has dynamically adapted to new ideas, emphasizing challenges and opportunities (Martín et al., 2019), so some topics within the curriculum will need to evolve more rapidly and, in some cases, components removed from the curriculum will need to be restored.

Today, as throughout its history, the field of Chemical Engineering needs to consider what minimum requirements and what set of principles should define the content of its core undergraduate curriculum and that can be framed by the following question: what product should an evolving undergraduate curriculum deliver? The requirements have not changed, but Chemical Engineers function and practice in a very different environment today (NASEM, 2022, p. 231). Engineering students today are asked to address more diverse challenges, with a body of knowledge and a toolbox, which extend beyond, what a core undergraduate curriculum can competently deliver in its entirety, so it must provide a mathematical framework for designing and describing chemical and physical processes, from the laws of conservation of matter and energy and mass and energy balances, in systems that are described by the continuity equation and by the thermodynamic relationships that define the equilibrium point, as well as the chemical and physical dynamics that materials follow to approach the equilibrium point, understanding that all this takes place in atoms and molecules in the states of matter, whether gas, liquid, solid or supercritical (NASEM, 2022).

The universities that grant the degree of Chemical Engineer in the world, such as the *Massachusetts Institute of Technology* (*MIT*) in the USA, the Liaoning University of Technology in China, the University of Santiago de Compostela, Spain and the Faculty of Chemistry of the UNAM, among other universities, offer several alternatives of specialization to the student, in response to the demands of the companies that hire Chemical Engineers, while studying the curriculum of the degree (Moliner, 2019). Therefore, by identifying the perception of the professors, the graduates and the companies that hire Chemical Engineers graduated at FES - Zaragoza, about the contents of the subject LPW in the 4th, 5th, 8th and 9th semesters and its congruence with the professional competencies needed by the chemical industry, recommendations can be suggested for this course in each of the semesters indicated, which are congruent with the labor market.

Methodology

In the graduate profile of the Chemical Engineering degree taught at FES - Zaragoza (Curriculum, 2013), it is established that the student will have the ability to conduct scientific research, to create production processes and to lead industrial projects, therefore, it is necessary to carry out a diagnosis to know the perception of the graduates, the professors and the companies that hire Chemical Engineers graduated at FES - Zaragoza, about the applicability of the contents of the subject LPW in the labor market and its congruence with the professional competencies needed by the chemical industry (Brown, 2019).

The degree program in Chemical Engineering at FES - Zaragoza consists of 9 semesters, with a total of 430 credits. It has a modular system and is divided into a basic cycle and a professional cycle. In the basic cycle, from the first to the third semester, students course subjects such as chemistry, mathematics, physicochemistry and basic science laboratories, so that they acquire adequate skills for the professional cycle. The professional cycle, from the fourth to the ninth semesters, enables students to develop skills, abilities, and attitudes in the different areas of Chemical Engineering.

In each semester of the professional cycle, a LPW is integrated. In this subject, the knowledge acquired in the same semester is integrated, becoming a perfect scenario to apply the theoretical knowledge acquired throughout the degree. In fact, as stated in the revision of the curriculum (2013), it is intended that, from very early stages of the students' training, they have a more direct contact with what will be their field of work, generating an engineering project derived from real situations, exposing it in the LPW Congress at the end of the semester, which allows them to acquire security, experience and develop those skills that will be very useful in the professional field.

It is in this part of the curriculum where it is expected that there could be an improvement in the subject program, since the specialists emphasize the importance of experimental activities from the beginning of the course and during the whole training cycle in Chemical Engineering, and in FES-Zaragoza this experimental continuity is broken during 4 semesters and has remain unchanged for 48 years. The research projects developed in the subject LPW have played a determining role in maintaining its validity, however, it is valid to consider that, through the knowledge of the perception of the graduates, the professors and the companies that hire Chemical Engineers trained in FES - Zaragoza, about the applicability of the contents of the subject LPW in the labor market and its congruence with the competencies needed by the chemical industry, it is possible to identify if it is necessary to propose changes, as several universities around the world have been doing.

The objective of this job is to develop a diagnosis that contributes to obtain the perception of the graduates, the professors and the companies that hire Chemical Engineers of FES - Zaragoza, about the applicability of the contents of the subject LPW in the labor market and its congruence with the professional competencies needed by the chemical industry.

To meet the objective, a study was developed based on a research process that proposes to solve certain situations related to the design of the study programs of the subject LPW, so we worked according to the projective research model which is part of the holistic spiral of research, based on previous researches. Projective research is one of the most complex types of research since it starts from a proposed reality, integrates the elements that are obtained for the interpretation of reality, involves all the actors of the process under study, visualizes and projects actions towards the objectives to reach a desired context to improve reality and proposes sustained actions to improve the analyzed context (González-Garay, 2019). The projective research is the most used research for the design of study programs, among other examples such as engineering projects, social intervention programs or computer programs, if they are supported by a research process. The project focused on conducting a diagnosis to know the perception of graduates, professors and companies that hire Chemical Engineers trained in FES - Zaragoza, so, data collection was done without numerical measurement. The research was done through surveys for graduates, for professors and for companies that hire graduates of Chemical Engineering trained at FES - Zaragoza, so that the views of the participants were framed by asking specific questions, leaving a space for respondents to expose their points of view, so that a mixed interview format was used, with closed and open questions.

Interviews were conducted with executives, asking open-ended questions to gather the direct perception of the company's personnel, using the interview guide to take advantage of the time allotted and achieve the objectives set.

Sampling unit: Graduates of the Chemical Engineering degree program at FES-Zaragoza with a maximum of 5 years of graduation, professors of the Chemical Engineering degree program at FES-Zaragoza who were teaching the LPW subject during the period of the survey or professors who, in their curricular experience, had taught this subject. In both cases, professors with at least 10 years of teaching experience were considered. Finally, we considered executives of companies that hire or have hired Chemical Engineers graduated from FES-Zaragoza.

In the instruments used, 26 questions were formulated for the professors and 31 questions for graduates. 56% of the questions involved the labor market and 44% of the questions involved professional competencies. The instruments initially proposed were changed and adapted with the observations made by the experts' judgment.

The instruments were validated using the technique suggested in qualitative research processes, such as observing the internal consistency of the instrument with which it is intended to measure a construct, based on the relationship shown by the items that make up the instrument or scale (Aranzabal et al., 2019).

Any measurement in the field of social and behavioral sciences must have two desirable characteristics which are validity and reliability and which in turn are key qualities of the so-called psychometric soundness of the instrument. The validity and reliability can be understood as indicated by Rodriguez & Reguant (2020). A common characteristic is to consider that while validity refers to the fact that it measures what it is intended to measure, reliability refers to the accuracy with which a measuring instrument measures what it measures (Aranzabal et el., 2019). For this research was used the Cronbach's alpha coefficient (α) described by Lee J. Cronbach (1951) (García et al., 2024), measuring the reliability linked to the homogeneity or internal consistency of an instrument.

The formula to calculate the Cronbach's Alpha Coefficient (α) is shown below:

$$\alpha = \frac{K}{K-1}\left[1 - \frac{\sum Vi}{Vt}\right]$$

Where:
K is the number of items
$\sum$Vi is the Variance sum of items
Vt is the total variance.

The calculations were made using Microsoft Excel version 2016.

Once the reliability of an instrument is calculated and a numerical value is obtained, the next step is to give meaning to that value. Reliability is expressed by a positive decimal number ranging from 0.00 to 1.00, from a lack of reliability to perfect reliability (Rodríguez & Reguant, 2020). The classic text by Nunnally (1978, cited by Rodriguez & Reguant, 2020) states that 0.70 is the minimum acceptable score. In this sense Barrios and Cosculluela (2013), cited by (Rodríguez & Reguant, 2020) conclude that adequate reliability ranges between 0.70

and 0.95 and point out that values very close to 1 may imply redundant items that do not provide relevant information about the attributes they are trying to measure.

Results

The research was conducted with a mixed approach, describing situations and events, specifying important properties and characteristics of the curriculum, measuring and evaluating components that contributed to support the content of a curricular design proposal for the Bachelor's Degree in Chemical Engineering taught at the Faculty of Highest Education - Zaragoza, through the labor market and the professional functions in which the graduates are immersed, to identify possible professional competencies needed in the LPW subject, so according to the mixed methods it was identified the convenience of focusing on a descriptive research, of the mixed type and with a projective research design. Mixed research approaches represent a set of systematic, empirical and critical research processes and involve the collection and analysis of quantitative and qualitative data, as well as their integration and joint discussion, to make inferences from all the information collected (meta-inferences) and thus achieve a better understanding of the phenomenon under study, without forgetting that those problems that need to establish trends, are better suited to a quantitative design; and those that need to be explored to obtain a deep understanding, are more suited to a qualitative design. When the problem or phenomenon is complex, the use of a mixed approach is recommended as is the case of this research work, being necessary the integration of the specialists' point of view to complement the resulting quantitative and qualitative information.

In Table 1 are presented the result of Cronbach's Alpha Coefficient (α) for the instrument applied to 18 professors of the Chemical Engineering degree program at FES – Zaragoza and from which 17 responses were received. The open-ended questions of the instrument for professors can be reviewed in Appendix A.

Table 1: Cronbach's Alpha Coefficient (α) Applied to the Survey Instrument for 17 Professors

Professor	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	Q 22	Q 23	Q 24	Q 25	Q 26	Σ
1	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5	5	5	5	5	5	5	128
2	4	4	5	5	3	4	4	4	5	5	5	5	4	5	5	1	4	4	5	5	4	5	5	4	4	5	113
3	5	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	5	5	4	3	4	4	3	3	3	116
4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	1	2	5	5	5	5	123
5	5	3	2	1	2	1	2	1	1	2	1	2	3	3	5	4	3	4	5	4	5	5	5	5	2	1	77
6	5	4	5	5	5	5	5	5	5	5	5	5	4	4	5	5	5	4	4	4	2	4	5	5	4	4	118
7	5	5	4	4	4	5	5	5	4	5	4	4	3	4	5	5	5	5	5	5	4	4	4	5	5	5	118
8	4	3	4	4	2	4	4	4	3	4	4	4	4	4	4	3	4	4	4	3	4	4	3	3	4	4	96
9	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	130
10	5	4	4	4	4	3	3	3	4	3	3	3	5	4	3	4	3	2	4	4	3	1	1	2	1	3	83
11	3	5	5	4	2	3	3	3	4	3	4	4	5	5	4	4	3	4	5	3	4	4	4	5	1	5	99
12	4	5	4	3	2	4	2	5	4	2	4	4	5	4	5	5	5	5	5	4	5	4	4	4	3	4	105
13	5	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	1	4	5	4	5	121
14	4	5	4	5	5	4	5	5	5	5	5	5	5	4	5	5	5	5	4	5	5	5	4	3	3	3	118
15	5	4	1	2	1	2	2	1	4	1	1	1	5	5	4	5	5	5	2	1	1	1	4	5	2	4	74
16	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	4	4	4	4	4	5	125
17	3	4	5	5	4	5	5	5	5	5	5	5	5	5	5	5	5	4	5	5	3	4	4	4	3	3	116
	0.5	0.5	1.3	1.3	1.9	1.4	1.4	1.8	1.1	1.8	1.7	1.4	0.5	0.4	0.3	1.1	0.6	0.6	0.6	1.1	1.6	2.0	0.9	0.9	1.7	1.2	291.89

Own elaboration with data from the survey applied to professors in September 2023.

K= # items	26.00
∑Vi= Variance sum of items	29.39
Vt= Total variance	291.89
Cronbach´s Alpha Coefficient (α)	0.935

The value of 0.935 gives a high reliability for the interpretation of the results.

Table 2 shows the result of Cronbach's Alpha Coefficient (α) for the survey instrument applied to 15 employers who hire Chemical Engineers from FES - Zaragoza. In the Appendix B are shown the open-ended questions to employers.

Table 2: Cronbach's Alpha Coefficient (α) Applied to the Survey Instrument for 15 Employers

Employer	Q 1	Q 2	Q 3	Q 4	Q 5	Q 6	Q 7	Q 8	Q 9	Q 10	Q 11	Q 12	Q 13	Q 14	Q 15	Q 16	Q 17	Q 18	Q 19	Q 20	Q 21	∑
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	2	1	1	1	2	1	27
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
5	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
7	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
9	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	21
10	1	1	1	1	1	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	30
11	1	1	1	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1	1	1	31
12	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	2	2	2	2	1	27
13	2	1	1	1	1	1	1	1	1	1	2	1	1	2	1	1	1	1	1	1	1	24
14	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	22
15	1	2	1	2	1	2	2	2	2	2	2	2	2	1	1	1	1	1	1	2	1	32
	0.06	0.06	-	0.12	0.06	0.16	0.20	0.16	0.16	0.16	0.24	0.22	0.20	0.16	-	0.06	0.06	0.06	0.06	0.16	-	16.20

Own elaboration with data from the survey of employers from October 20 to 24, 2023.

K= # items	21.00
∑Vi= Variance sum of items	2.36
Vt= Total variance	16.20
Cronbach´s Alpha Coefficient (α)	0.90

In Table 3 are shown the result of Cronbach's Alpha Coefficient (α) for the survey instrument applied to 538 graduates of Chemical Engineering degree program at FES – Zaragoza, of which 85 responses were received, that is, 15.79% of the population invited to participate.

In the Appendix C are presented the open-ended questions for graduates.

Table 3: Cronbach's Alpha Coefficient (α) Applied to the Survey Instrument for 85 Graduates

Graduates	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	…	Q27	Q28	Q29	Q30	Q31	
1	**5**	**5**	**5**	**5**	**4**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**5**	**4**	**2**	**2**	**127**
2	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**4**	**4**	**4**	**4**	**3**	**3**	**123**
3	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**2**	**5**	**2**	**2**	**5**	**144**
4	**4**	**5**	**3**	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**5**	**5**	**5**	**5**	**5**	**2**	**5**	**2**	**5**	**5**	**136**
5	**5**	**5**	**5**	**1**	**1**	**1**	**5**	**5**	**5**	**1**	**1**	**5**	**5**	**5**	**5**	**1**	**1**	**5**	**5**	**3**	**97**
6	**4**	**5**	**4**	**4**	**4**	**4**	**5**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**4**	**2**	**4**	**122**
7	**5**	**4**	**4**	**2**	**4**	**4**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**4**	**5**	**5**	**4**	**122**
8	**5**	**5**	**5**	**3**	**1**	**1**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**5**	**4**	**5**	**4**	**114**
9	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**4**	**5**	**5**	**2**	**5**	**3**	**5**	**3**	**4**	**3**	**4**	**4**	**119**
10	**5**	**5**	**5**	**5**	**2**	**2**	**4**	**2**	**5**	**5**	**2**	**2**	**5**	**5**	**5**	**1**	**1**	**4**	**2**	**1**	**96**
11	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**4**	**3**	**5**	**2**	**136**
12	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**5**	**140**
13	**5**	**5**	**5**	**4**	**3**	**4**	**4**	**4**	**5**	**4**	**5**	**4**	**5**	**5**	**5**	**1**	**4**	**1**	**1**	**4**	**105**
14	**4**	**5**	**4**	**4**	**2**	**5**	**4**	**5**	**3**	**4**	**4**	**4**	**5**	**5**	**5**	**4**	**5**	**4**	**3**	**5**	**125**
15	**5**	**4**	**5**	**5**	**5**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**1**	**3**	**3**	**3**	**3**	**107**
16	**5**	**4**	**2**	**3**	**4**	**3**	**4**	**3**	**5**	**5**	**5**	**5**	**3**	**4**	**4**	**1**	**3**	**3**	**3**	**3**	**115**
17	**4**	**4**	**4**	**5**	**5**	**5**	**4**	**4**	**4**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**132**
18	**4**	**5**	**5**	**2**	**4**	**4**	**5**	**4**	**4**	**4**	**5**	**4**	**4**	**5**	**5**	**5**	**4**	**5**	**5**	**4**	**135**
19	**4**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**3**	**4**	**4**	**5**	**1**	**3**	**5**	**2**	**3**	**124**
20	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**2**	**5**	**2**	**2**	**2**	**5**	**5**	**5**	**1**	**5**	**5**	**3**	**5**	**110**
…	**4**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**3**	**1**	**1**	**3**	**116**
32	**4**	**5**	**4**	**3**	**3**	**4**	**4**	**4**	**3**	**4**	**5**	**5**	**5**	**5**	**5**	**1**	**4**	**5**	**5**	**4**	**113**
33	**4**	**4**	**3**	**5**	**4**	**4**	**5**	**5**	**4**	**4**	**4**	**3**	**3**	**3**	**5**	**1**	**2**	**1**	**1**	**2**	**103**
34	**5**	**5**	**4**	**4**	**4**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**2**	**2**	**2**	**2**	**3**	**114**
35	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**2**	**4**	**1**	**3**	**122**
36	**5**	**5**	**1**	**2**	**2**	**2**	**4**	**4**	**4**	**4**	**5**	**5**	**4**	**5**	**5**	**1**	**1**	**4**	**3**	**1**	**105**
37	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**4**	**4**	**3**	**3**	**139**
38	**5**	**4**	**1**	**5**	**5**	**3**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**2**	**5**	**4**	**2**	**1**	**1**	**1**	**115**
39	**5**	**5**	**5**	**4**	**5**	**4**	**4**	**4**	**3**	**3**	**4**	**5**	**5**	**5**	**5**	**3**	**4**	**4**	**5**	**4**	**118**
40	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**5**	**147**
41	**2**	**4**	**2**	**4**	**4**	**4**	**4**	**5**	**2**	**2**	**5**	**5**	**5**	**5**	**5**	**1**	**4**	**3**	**2**	**4**	**108**
42	**1**	**4**	**4**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**1**	**1**	**5**	**1**	**4**	**5**	**5**	**4**	**114**
43	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**2**	**1**	**1**	**2**	**108**
44	**5**	**4**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**4**	**4**	**5**	**5**	**1**	**4**	**4**	**4**	**4**	**125**
…	**5**	**5**	**3**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**5**	**5**	**1**	**5**	**5**	**4**	**139**
60	**5**	**5**	**3**	**1**	**3**	**3**	**1**	**5**	**5**	**4**	**5**	**5**	**4**	**5**	**5**	**1**	**5**	**5**	**5**	**1**	**114**
61	**4**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**4**	**4**	**5**	**5**	**5**	**5**	**5**	**2**	**4**	**4**	**3**	**4**	**132**
62	**5**	**4**	**4**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**4**	**2**	**2**	**2**	**3**	**2**	**116**
63	**5**	**5**	**4**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**1**	**1**	**1**	**3**	**1**	**110**
64	**2**	**4**	**2**	**4**	**4**	**5**	**5**	**5**	**5**	**5**	**4**	**4**	**4**	**5**	**5**	**2**	**4**	**4**	**2**	**3**	**126**
65	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**2**	**5**	**5**	**5**	**5**	**133**
66	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**4**	**4**	**4**	**4**	**140**
67	**2**	**2**	**1**	**5**	**5**	**1**	**1**	**1**	**4**	**5**	**5**	**4**	**4**	**5**	**5**	**4**	**5**	**5**	**5**	**4**	**120**
…	**5**	**4**	**4**	**4**	**4**	**5**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**5**	**5**	**3**	**5**	**4**	**2**	**2**	**133**
79	**5**	**5**	**5**	**4**	**4**	**5**	**5**	**5**	**4**	**3**	**5**	**4**	**5**	**5**	**5**	**3**	**5**	**4**	**3**	**1**	**118**
80	**5**	**5**	**2**	**2**	**2**	**2**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**3**	**5**	**5**	**5**	**5**	**134**
81	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**1**	**1**	**5**	**1**	**115**
82	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**3**	**4**	**2**	**2**	**4**	**142**
83	**5**	**5**	**4**	**4**	**5**	**5**	**4**	**4**	**5**	**5**	**4**	**4**	**5**	**5**	**5**	**1**	**1**	**1**	**1**	**1**	**101**
84	**5**	**5**	**5**	**4**	**4**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**3**	**5**	**2**	**4**	**5**	**5**	**3**	**129**
85	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**4**	**5**	**5**	**5**	**5**	**5**	**5**	**5**	**1**	**4**	**2**	**3**	**1**	**120**
	1.14	**0.67**	**1.30**	**1.08**	**0.93**	**0.95**	**0.70**	**0.58**	**0.48**	**0.70**	**0.81**	**0.73**	**0.87**	**1.07**	**0.11**	**1.99**	**1.84**	**1.99**	**2.18**	**1.89**	**146.95**

Own elaboration with data from the survey applied to graduates in September 2023.

K= # items	31.00
∑Vi= Variance sum of items	37.12
Vt= Total variance	146.95
Cronbach´s Alpha Coefficient (α)	0.77

The value of 0.77 gives an acceptable reliability for the interpretation of the results.

Discussion

Organizations such as the FiiDEM Alliance that recommend combining academic study with supervised work experience, they also recommend completing a school period in the industry, in addition to inducing future engineers to carry out real industrial projects, in addition to recommending continuous experimentation, from the beginning of the career in the laboratories of the university itself and without interruptions, until the completion of the real industrial project in the last undergraduate period (NASEM, 2022). In the curriculum of the undergraduate degree in Chemical Engineering taught at FES-Zaragoza there are the LPW subjects of the semesters 4th, 5th, 8th and 9th in which experimentation is not currently performed, being these subjects the resource that can be used to implement the recommendations of the specialists, to increase the competences of the students combining the engineering research project of the 9th semester, with the opportunity to assign them a company to complete their professional training (Lenihan et al., 2020).

The LPW subjects are dynamic and flexible as it allows working on topics of interest and current affairs that are adapted to the industrial and social needs of the time, for example, Chemical Engineering students are very interested in topics related to the environment and the production of biomaterials, and the LPW courses are the appropriate scenario to study and analyze these types of projects with the approach that corresponds to each module and that, over time, have played a decisive role in maintaining the validity of the curriculum.

Recommendations

Cork Institute of Technology (*CIT*) of Ireland is an institution of teaching, learning and research excellence and quality for the benefit of the student and for the benefit of society. *Cork Institute of Technology* has been teaching Chemical Engineering since 1979 and is well established to meet the demand for Chemical Engineering graduates in different areas such as Chemical, Food and Beverage, Oil and Gas and Pharmaceuticals. From 2010 to 2020 *Cork Institute of Technology* incorporated Bioengineering based teaching modules such as Principles of Bioprocess Engineering, Biopharmaceutical Engineering and Bioreactor Design to meet the demand in the Biopharmaceutical sector (Lenihan et al., 2020). Even though the constant updating of the curriculum at *Cork Institute of Technology* is visible, they detected a problem; it took 1 to 2 years for graduates to be hired and decided to conduct a study to identify possible solutions to reduce the hiring time of graduates. They conducted a census of all chemical industry companies within Ireland and confirmed that the pharmaceutical and biotechnology sectors were key elements for their country, as well as contributing 58% of exports nationally. Also, as part of the strategy, they identified companies in the chemical industry that were within a 100-kilometer radius of the *Cork Institute of Technology*. The *Cork Institute of Technology* took the recommendations of specialists in the training of Chemical Engineers and decided to approach companies to reach collaboration agreements so that Chemical Engineering students could carry out their last undergraduate project within the company. To this end, at the *Cork Institute of Technology*, the competencies in Chemical Engineering were developed by combining the engineering research project and the opportunity to assign them to a company to complete the project in the last year of undergraduate studies, concluding that a favorable synergy is achieved, compared to the results when not combined (Lenihan, 2020). Based on the criteria of the *Cork Institute of Technology* it is also important that the academic staff is familiar with the industrial environment and has worked as a professional in Chemical Engineering to facilitate the integration tasks of the educational project (Lenihan, 2020).

Conclusions

- The Chemical Engineering degree program at FES - Zaragoza must create incentives and practices in the industry, to share Chemical Engineering content, ensuring that the exchange promotes access to high quality content intended for both students and professionals in Chemical Engineering, in addition to have a period of experience in the industry.
- The Chemical Engineering degree program at FES - Zaragoza should approach companies to achieve collaboration agreements for Chemical Engineering students to carry out the last undergraduate project within a company.
- Experiential and frequent learning should be included from the beginning of the career, and without interruptions, through laboratory practices and virtual simulations, as well as experiential learning in industry should be reinforced, eliminating barriers, to offer internships to Chemical Engineering students in a systemic way in companies or in university laboratories.
- Chemical Engineers at FES - Zaragoza should be induced to carry out real industrial projects, addressing a real problem of current importance and must be coupled to the needs of industry and society.
- Commonly universities have state-of-the-art laboratories that are managed by the university itself or by some private company, with specialized applications, aligned to industry needs.
- Create effective connections between individual core courses with empirical learning through virtual or physical laboratory experiences.
- Place greater emphasis on statistics in the modern database context, with highest capacity computing systems, with the use of robust, high-fidelity models and methods.
- The market study, the technical study and the production capacity that is carried out in the 4th semester LPW, must be related to the national chemical industry, and compared with the installed capacity of a company to increase the professional competences of the students and must be compared with similar processes of the national chemical industry to bring the students closer to the labor market, adapting the project to the needs of the industry.
- To increase the professional competencies of the students, in LPW of 5th semester, the results should be compared with the equipment and systems used in the national chemical industry and perform laboratory practices when designing process equipment from the mechanical point of view, when designing systems for the handling of materials in the chemical process industry, and when designing mechanical separation and mixing systems for the chemical industry. The specifications and standards used in the design of process equipment in a company of the national chemical industry or using simulators should be compared.

- The selection and design of homogeneous and heterogeneous reactors and the results of the simulation and optimization of the 8th semester LPW project should be compared with the results of a reactor used in the chemical industry to bring students closer to the job market, including experimental activities aligned with the needs of the industry, in laboratories of the University itself, with emphasis on statistics in the modern context of databases.
- The 9th semester project must be carried out at the facility of a chemical company that processes a product that is the same or like the product assigned in the project, promoting high quality supervised content, and thus completing a semester of industry experience.
- The results of the financial and economic study and the rates used by the investors of the 9th semester LPW project should be compared with a company in the chemical industry to increase the competencies of the students, without forgetting that Business Development is important, but it is recommended that it be part of individual courses, after the formal curriculum of Chemical Engineering, so it should not be part of the formal curriculum of the bachelor's degree.
- In the LPW projects of semesters 4, 5 and 8, experimental activities should be carried out in the laboratories of FES-Zaragoza and simulators should be used to verify results.
- To increase students' competencies, projects in semesters 4, 5, 8 and 9 should be carried out on products produced in the Mexican Republic.
- The use of simulators for projects in semesters 4, 5, 8 and 9 should be a mandatory tool to create effective connections between courses and the effective and seamless incorporation of statistics and computational mathematical thinking.
- Biotechnology should be integrated as a required or elective course for Chemical Engineers.

Acknowledgements

Sincere thanks to each one of the participants in this research, professors, graduates, and employers, all interested in updating and improving the academic level of the Chemical Engineering students of the Faculty of Highest Studies - Zaragoza of the National Autonomous University of Mexico, to make them more useful to society and more competitive in the labor market.

Appendices

Appendix A

Questionnaire for professors of Chemical Engineering degree program at the Faculty of Highest Education – Zaragoza, with at least of 10 years of teaching experience.

Please answer considering the following options.

1) Definitely not 2) Probably not 3) Undecided 4) Probably yes 5) Definitely yes

#	Questions	R
Q1	The subject Laboratory and Projects Workshop (LPW) has 4 theoretical laboratories and 2 empirical laboratories. Do you consider it pertinent to include experimental activities in LPW in semesters 4, 5, 8 and 9?	
Q2	Should LPW in semesters 4, 5, 8 and 9 be linked to a company that produces same or similar product than the product assigned in the project?	
Q3	If the LPW of semesters 4, 5, 8 and 9 were carried out on products that are produced in Mexico, would they increase the skills of the students?	
Q4	If the LPW 4's market and technical study were conducted based on the processes that are used in the national chemical industry, would the students' competences increase?	
Q5	If the production's capacity of the chemical process analyzed in LPW 4 is compared with the capacity of a company that exploits the same process in the national chemical industry, would the students' competences increase?	
Q6	If the industrial process analyzed in LPW 4 were carried out according to the processes that are used in the national chemical industry, would it bring the students closer to the job market?	
Q7	In LPW 5, process equipment is designed from the mechanical point of view, material handling systems are designed for the chemical process industry, and mechanical separation and mixing systems are designed for the chemical industry. Would the students' competencies increase if the results were compared with an engineering firm and/or a process equipment manufacturer?	
Q8	In LPW 5, the specifications and standards for the design of process equipment are analyzed from a mechanical point of view. Would the students' competencies be enhanced by comparing their application in an engineering firm and/or process equipment manufacturer?	
Q9	In LPW 8, homogeneous and heterogeneous reactors are selected and designed. Would comparing the results with a reactor used in the national chemical industry bring the students closer to the job market?	
Q10	In LPW 8, processes are simulated and optimized using mathematical models. Would the students' competencies increase if the results were compared with a process in the national chemical industry?	
Q11	In LPW 9, a financial and economic study of a project is prepared. Would the students' competencies increase if the results were compared with a company in the national chemical industry?	
Q12	In LPW 9, financial statements are prepared to determine the ratios used by an investor in making decisions about a project. Would the students' competencies be enhanced by comparing the results with a chemical company with investment projects?	

Q13	Should LPW 9 project be conducted at the facility of any chemical company that processes same or similar product than the product assigned in the project?	
Q14	If LPW 9 were to be carried out at a company's facility, do you think it would facilitate the hiring of graduates?	
Q15	Do you think it is necessary to reinforce experiential learning in industry by offering internships to Chemical Engineering students in a systemic way?	
Q16	Would it be useful if through LPW of semesters 4°, 5°, 8° and 9° to promote internships in the chemical industry, to share Chemical Engineering content to students?	
Q17	Can LPWs in semesters 4, 5, 8 and 9 be used as a learning and innovation infrastructure, from university education to the workplace?	
Q18	Should the LPWs of semesters 4, 5, 8 and 9 be used as a link to bring Chemical Engineering students closer to industry?	
Q19	Should the 4th, 5th, 8th, and 9th semester LPW professors be familiar with the industrial environment and have worked as a Chemical Engineer in industry?	
Q20	Would the students be increased if the LPW project for semesters 4, 5, 8 and 9 were the same, with the corresponding module focus (Process Analysis, Materials Handling, Process Design and Project Development)?	
Q21	As an LPW professor for semesters 4, 5, 8 or 9, do you use electronic simulators for industrial chemical processes every semester?	
Q22	Have you conducted LPW projects in semesters 4, 5, 8 or 9 involving Biotechnology processes?	
Q23	Do you consider that the study of Biotechnological processes should be an elective subject for Chemical Engineers?	
Q24	Should Process and Product Control be an elective subject for Chemical Engineers?	
Q25	Should Data Science be an elective subject for Chemical Engineers?	
Q26	Should Business Development be an elective subject for Chemical Engineers?	
Q27	Based on your experience, how can we increase the competencies of Chemical Engineering students at FES-Zaragoza?	
Q28	Would you like to add any comments about the LPW subjects?	

Appendix B

Questionnaire for employers that hire Chemical Engineering graduated from FES-Zaragoza.

Please answer considering the following options.

1) Yes, it is useful 2) No usefulness

#	Questions	R
Q1	A product is designed knowing the characteristics of the current product, the consumer profile is identified, consumer expectations are identified and the proposal for a new product is presented.	
	Comments:	
Q2	Through market research, a supply vs. demand interpolation is carried out and the distribution and marketing channels for the proposed product are identified.	
	Comments:	
Q3	The most convenient production process is selected considering the availability of raw material and the suggested location for the plant, performing the mass balance and energy balance for the selected process.	
	Comments:	
Q4	Properties' prediction of the new compound is made, supported by research.	
	Comments:	
Q5	The stages of a project are studied, specifications and standards for equipment design are reviewed, the physical and chemical properties of the materials used in the construction of equipment are studied, and the selection and specification of materials are made.	
	Comments:	
Q6	Material handling systems in the chemical process industry are selected and designed, determining the variables involved in material handling, correlating the variables with experimental observations, making rheological determinations of non-Newtonian fluids and sizing the systems for solids transport and fluid transport.	
	Comments:	
Q7	Mechanical separation systems in the chemical process industry are selected and designed, making the experimental determination of the variables involved in the selection and design of a mechanical separation system for materials.	
	Comments:	
Q8	Mixing systems in the chemical process industry are selected and designed, making the experimental determination of the main variables involved in the selection and design of a material mixing system.	
	Comments:	
Q9	Crushing and milling systems in the chemical process industry are selected and designed, making the experimental determination of the variables involved in the selection and design of a crushing and milling system for materials.	
	Comments:	
Q10	Sizing of mechanical separation, fluid transport and mixing equipment is performed.	
	Comments:	
Q11	Homogeneous and heterogeneous reactors are selected and designed through process simulation and optimization using mathematical models.	
	Comments:	

Q12	Reaction systems are studied, analyzing the main phenomenological models, determining experimentally the main variables, selecting the mathematical models based on experimental observation values, analyzing the selection and design criteria to select and design the reaction system.	
	Comments:	
Q13	Process simulation and optimization is performed by using mathematical models for a process step and for the complete process, analyzing the behavior through simulation, analyzing the process optimization criteria and applying the process synthesis criteria in the process design.	
	Comments:	
Q14	For process control systems, the variables involved in the dynamics of a process step are determined, analyzing the process with mathematical model simulation, analyzing the dynamics under a control system, comparing the dynamic behavior under different systems to select and design a process control system.	
	Comments:	
Q15	For total investment, fixed assets, deferred assets and working capital are identified.	
	Comments:	
Q16	The financial structure identifies the capital stock and sources of financing.	
	Comments:	
Q17	The revenue budget includes sales, discounts and rebates and net sales invoiced.	
	Comments:	
Q18	The expense budget analyzes and integrates fixed and variable costs.	
	Comments:	
Q19	The pro forma financial statements include the balance sheet, income statement and cash flow statement.	
	Comments:	
Q20	The net present value, the internal rate of return and the capital recovery time are calculated.	
	Comments:	
Q21	A sensitivity analysis is performed considering the inherent risks of a project and the risk prevention strategy.	
	Comments:	
Q22	What are the instrumental, interpersonal, and systemic competencies your company is looking for when hiring Chemical Engineers?	
Q23	What are the academic and professional competencies that your company needs when hiring Chemical Engineers?	
Q24	Do you have any additional recommendations or comments?	

Appendix C

Questionnaire for graduates of Chemical Engineering degree program at FES-Zaragoza, with a maximum of 5 years after graduating.

Please answer considering the following options.

1) Definitely not 2) Probably not 3) Undecided 4) Probably yes 5) Definitely yes

#	Questions	R
Q1	The subject Laboratory and Projects Workshop (LPW) has 4 theoretical laboratories and 2 experimental laboratories, should experimental activities be included in each LPW?	
Q2	Must LPW of 4, 5, 8 and 9 semesters be linked to a company that produces a product that is same or like the product assigned in the project?	
Q3	Should LPW of 4, 5, 8 and 9 semesters be carried out on products produced in Mexico, to increase students' skills in the national chemical industry?	
Q4	Does the market and technical study conducted in LPW 4 must be related to the national chemical industry?	
Q5	Should the production capacity of the process being analyzed in LPW 4 be compared with the installed capacity of any company operating the same process in the national chemical industry?	
Q6	Should the process studied in LPW 4 be compared with similar processes in the domestic chemical industry?	
Q7	In LPW 5, process equipment is designed from the mechanical point of view, systems for material handling in the chemical process industry are designed and mechanical separation and mixing systems for the chemical industry are designed. Should the results be compared with equipment and systems used in the national chemical industry?	
Q8	In LPW 5, the specifications and standards for the design of process equipment are analyzed from the mechanical point of view, should their application in any company of the national chemical industry be compared?	
Q9	In LPW 8, homogeneous and heterogeneous reactors are selected and designed, should the results be compared with any reactor used in the national chemical industry?	
Q10	In LPW 8, processes are simulated and optimized using mathematical models, should the results be compared with any process in the national chemical industry?	
Q11	In LPW 9, the financial and economic study of a project is elaborated, should the results be compared with a company of the national chemical industry?	
Q12	In LPW 9, financial statements are prepared to determine the ratios used by an investor in making decisions on a project. Should the results be compared with any chemical company with investment projects?	
Q13	Should the LPW 9 be conducted at the facility of a chemical company that processes the same or similar product assigned in the project?	
Q14	If LPW 9 were to be carried out at a company's facility, do you think it would facilitate the hiring of graduates as professionals in Chemical Engineering?	
Q15	Is there a need to reinforce experiential learning in industry by offering internships to Chemical Engineering students in a systemic way?	
Q16	If through LPW of 4, 5, 8 and 9 semesters promote internships in the chemical industry, would it be useful to share Chemical Engineering content to students?	

Q17	Can LPW of 4, 5, 8 and 9 semesters be used as a learning and innovation infrastructure, from university education to the workplace?	
Q18	Should LPW of 4, 5, 8 and 9 semesters be used as a link to bring Chemical Engineering students closer to industry?	
Q19	Should the LPW professors of 4, 5, 8 and 9 semesters be familiar with the industrial environment and have worked as a Chemical Engineer?	
Q20	Would students' competencies be increased if the LPW were the same in 4th, 5th, 8th, and 9th semesters, with the corresponding module focus (Process Analysis, Materials Handling, Process Design and Project Development)?	

Please evaluate considering the following options:

1) Nothing 2) Very Little 3) Some 4) Quite a lot 5) A lot

Q21	Energy and Mass Balance?	
Q22	Transport Phenomena?	
Q23	Thermodynamics?	
Q24	Mass transfer?	
Q25	Reactor Engineering?	
Q26	Equipment design?	
Q27	Biotechnology?	
Q28	Process and Product Control?	
Q29	Data Science?	
Q30	Business Development?	
Q31	Electronic simulators for chemical processes.	

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