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STUDY ON STUDENT´S PREVIOUS BACKGROUND, INTEREST, INSIGHT, PREFERENCES AND SUCCESS RATE IN THE SUBJECT CHEMISTRY IN SEVERAL ENGINEERING DEGREES

at the 11th International Conference on Education and New Learning Technologies held in Palma, Mallorca, Spain, 1st-3rd of July 2019.

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STUDY ON STUDENT´S PREVIOUS BACKGROUND, INTEREST, INSIGHT, PREFERENCES AND SUCCESS RATE IN THE SUBJECT CHEMISTRY IN SEVERAL ENGINEERING DEGREES

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Abstract

Several Degrees in Engineering taught at the Universitat Jaume I, such as Chemical, Industrial Technologies, Electrical, Mechanical and Agrifood and Rural, include in their curriculum program a subject on General Chemistry (as Basic Training), as well as one about enlargement of Chemistry (as optional). The groups are made of students from the five Degrees, randomly distributed. As in other Degrees, the students can get access without having studied Chemistry subjects in the pre-University education period (High School or Vocational Training), and then with a weak background knowledge on this topic. The subject "Chemistry for Engineering" (General Chemistry) consists in seven Thematic Blocks: Chemical link, Acid/base, Metal Complexes, Solubility, Redox, Bases of Organic Chemistry and Industrial Applications. A comparative study among the students from several Degrees in Engineering about their experience on studying "Chemistry for Engineering" was carried out during five academic years, considering the following points: previous background on chemistry, personal opinion, perception and interest on the subject and its didactic content, the acquired learning outcomes, the developed competencies, and the success rate. From the obtained data, extracted from 320 questionnaires and the corresponding final qualifications, which are calculated from the grades reached in the different evaluation parts (tutorials, practical, oral presentations and written exams), obtained by the students, we can highlight the following findings: first, 81% of the students of Chemical Engineering have previously pursued Chemistry subjects, face to 20-30% for the other Engineering Degrees; second, Industrial Technologies has the least percentage of students having pursued Chemistry courses in the pre-University education, as they preferred to choose Physics and Technical Drawing as optional subjects; third, 94% of the students of Electrical and Mechanical Engineering have previously studied the topic redox (oxidation-reduction) equilibria, wherein they are highly interested; four, most of the Engineering students, whatever the especialization, have great calculus skills, offering them many guarantees to pass the subject, as the final exam consists in the resolution of numerical problems. In fact, nearly 86% of the students pass the subject each academic year, taking into account the two calls

Keywords: Background; Chemistry; Competencies; Engineering; Learning.

1 INTRODUCTION

The guidelines of the European Higher Education Area (EHEA) state that students must be at the center of the teaching / learning. This means the preferences and needs of students should be prioritized in the design of the education system. To meet the standards of European convergence, the Universitat Jaume I (UJI) has established its teaching methodology considering the characteristics of students. Thus, the curriculum and the course syllabus of the grades have been prepared according to student interest and usefulness in their future career.

For engineers, regardless of their area of expertise, it is essential to have a basic understanding of chemistry. Undoubtedly, at some point in their career they will need to know the properties of a compound or the characteristics of a chemical process to solve a practical problem. Nevertheless, we must also take into account engineering students do not usually have a special preference for Chemistry. In addition, they can access grades by several ways, such as High School, Vocational

Training and specific exams for adults, where the taught content might be rather different, and diverse centres, which may not teach chemistry courses or just some topics, included in other subjects.

The UJI has included the subject "Chemistry for Engineering" (EX1006) in some degrees in Engineering: Mechanics (IM), Agri - Food and Rural Affairs (IAMR), Electric (IE), Industrial Technologies (ITI) and Chemical (IQ). It is a compulsory subject with a total teaching load of 6 ECTS, taught at the first semester of the first academic year. It has 5 groups, each one with a maximum capacity of 80 students. For each group, the theoretical content (3.8 ECTS) is taught by a single teacher, but they are divided into different subgroups for other parts of the subject: problems (0.5 ECTS), tutorials (0.5 ECTS) and laboratory (1 ECTS). This subject is taught by 14 teachers, who belong to the areas of knowledge of Analytical Chemistry, Physics (Department of Physical and Analytical Chemistry, QFA), Inorganic and Organic (Department of Inorganic and Organic Chemistry, QIO), from the High School of Technology and Experimental Sciences (ESTCE). This subject aims students acquire a basic knowledge of general chemistry. The content of this subject is quite extensive, and continues and partially overlap to those taught at pre - university stages. It includes seven thematic units: Atomic structure, Acidic-basic equilibria, complexes, Solubility, Redox, Organic Principles and Industrial Applications. The evaluation consists of: theoretical examination, consisting of solving numerical problems (70%), continuous assessment, consisting of theory tests (15%), work to hand in (5%), and laboratory (10 %).

Since its inception in 2011, it was found students experience difficulty to follow the matter, even those with good qualifications in other subjects. It has also been observed that most students have never attended courses in chemistry and their initial level was relatively low.

The objective of this paper is investigating about previous competencies in chemistry students, according to the studied degree, and how they influence the chances to pass the subject. We aim to know the interest and preferences of students in relation to the contents of the subject, and their perception about the difficulty of each part. It is expected to propose new strategies to increase academic results and student interest in the subject.

2 METHODOLOGY

At the end of the academic year, students from each grade were asked for responding a questionnaire requested (anonymously and optional), on their previous skills in chemistry, their preferences regarding the subject content, their perception on the subject and if they have passed the subject. No distinction was made between students enrolling for the first or second or successive. The different questions were:

1 Have you previously studied Chemistry or subjects related to chemistry?
   - Yes: I was interested in chemistry.
   - Yes: but I was not interested in chemistry.
   - No, this was not taught at my center.
   - No, I preferred other subjects.
   - No, but I completed related concepts in other scientific subjects.

   Questions 1a, 1b, 1c and 1d are exclusive. Sum of 1a + 1b + 1c + 1d must equal the total number of students in each subject. Question 1e can be only responded by who have responded to 1c and 1d.

2 Indicate your interest in: (0 I am not interested - 10 I am very interested):
   - Atomic structure:
   - Acidic-basic equilibria:
   - Complexes:
   - Precipitation:
   - Redox:
   - Principles of Organic Chemistry:
   - Industrial Applications:
   - The entire subject:
   - The studied contents will be useful for my future career (0 will not be helpful - 10 will be very useful)

3 Did you find it easy to understand...? (0 very difficult - 10 very easy):
   - Theory:
   - Problem resolution:
   - Laboratory:
4 Have you passed the subject? : Yes / No
5 Comments

3 RESULTS ANS DISCUSSION

20 valid questionnaires distributed among the following grades were obtained with the following distribution Engineering Mechanics, 70; Agri - Food and Rural Affairs , 65; Electrical, 73; Industrial Technologies, 54; and Chemistry, 58. The results are presented in Tables 1-4 and their interpretation are described in the following subsections.

3.1 Previous competencies in Chemistry

We inquiry about previous competitions in chemistry students, and the reasons why they had / had not acquired them (Table 1):

Table 1. Previous competencies in chemistry.

Have you previously studied chemistry or related subjects?	***Mechanics***	***Agri - Food and Rural Affairs***	***Electric***	***Industrial Technologies***	***Chemical***
Yes: I was interested in chemistry	6	10	7	2	44
Yes: but I was not interested in chemistry	11	8	15	9	3
No, this was not taught at my center	19	15	20	10	5
No, I preferred other subjects	35	32	31	33	6
No, but I completed related concepts in other scientific subjects	49	39	46	41	11

It is observed that the percentage of students in the Degree of Chemical Engineering who have studied chemistry before enrolling in grade is much higher (86%) than the rest (20-30%). It is logical, since it is necessary to have advanced knowledge in chemistry to study and implement processes in the chemical industry.

Virtually all students in IQ (94%) who had studied chemistry previously did it because they have a real interest in the subject. It is an expected result since they have been selected to start university studies within the same branch of knowledge. This percentage was much lower for other Degrees in Engineering (18-56%). In these cases, the students chose chemistry as optional because they thought they would be useful to pursue their respective degrees.

Without considering IQ students, the reason for not choosing Chemistry was mainly (60-78%) because they preferred other subjects, such as Physics or Technical Drawing. It is understandable, as these subjects are critical in almost all engineering grade, and having a good background is necessary to overcome most of the subjects in Engineering Grades, while chemistry is rather secondary. It is also seen that there are centres that do not offer Chemistry, which should be reconsidered, since it is a basic subject for any scientist.

Among the students who have not previously studied chemistry, many have learned some chemistry concepts in other scientific subjects, raising the percentage of students with previous skills to 88-100%. IE and IM students had studied about the redox theme in subjects of Physics and / or related to electricity. In fact, this topic is the most interesting for these Grades, especially in regard to production, properties, effects on the matter, and applications of electric current.

3.2 Prior knowledge and passing the subject

It was investigated to what extent have studied subjects of chemistry at the pre - university stage could have helped to pass the course (Table 2).

Table 2. Percentage of students passing the subject, depending on the degree and prior knowledge..

Percentage of students who have passed the subject	*Mechanics*	*Agri - Food and Rural Affairs*	*Electric*	*Industrial Technologies*	*Chemical*
Over all the students	77	82	85	91	97
Over those having previously studied Chemistry or related subjects	80	87	92	94	98
Over those having not studied Chemistry or related subjects	76	80	82	90	93

The proportion of students passed the subject, considering the two calls, is relatively high (86%). This number is higher among those who had previously studied Chemistry or related subjects. Therefore, a good background in Chemistry acquired in High School/Vocational Training helps to understand the concepts taught in Grade, as they are a continuation of them. However, the lack of prior competences can be compensated by an intensive study of the subject, dedication, taking remedial classes and hard work, as evidenced by the high percentage of students having passed the subject.

3.3 Student interest and preferences

He inquired about the interests and preferences of students on the subject and in each of the themes, as well as on their opinion about the usefulness of the subject (Table 3).

Table 3. Interest and preferences of the students about the contents of the subject.

Indicate your interest in:	*Mechanics*	*Agri - Food and Rural Affairs*	*Electric*	*Industrial Technologies*	*Chemical*
Atomic structure	0.9	1.8	1.5	2.1	4.3
Acid-base	1.6	3.8	2.6	4.8	5.2
Complexes	2.3	2.9	2.7	2.1	6.9
Precipitation	3.2	5.2	3.8	5.9	7.8
Redox	9.5	8.9	9.7	9.4	8.4
Principles of Organic Chemistry	5.5	8.7	4.5	7.7	9.4
Industrial applications	9.4	7.9	8.6	9.5	9.2
The entire subject	2.9	4.0	3.5	5.8	8.1
The studied content will be useful for my future career	2.8	6.3	3.9	7.6	9.8

We can detect a correlation between the interest of Engineers for the contents of the subject and their usefulness for their future career. Those with a more positive attitude are IQ, then the ITI whose studies are related to industrial processes involving chemical reactions, and therefore require a larger background in general chemistry.

The topic raising the higher interest are; Redox (especially for IE and IM), because, as it includes electrics, it resembles to Physics; Industrial Applications, where practical applications of chemistry are described (therefore can see the utility of Chemistry), and Principles of Organic Chemistry, as chemical compounds of high industrial interest are generally organic. The least interesting topic was atomic structure, which, after all, involves abstract theoretical concepts difficult to visualize. The acid-base complex and precipitation equilibria do not interested them too much.

Although initially the engineers often express a negative attitude towards chemistry, after completing the course their opinion towards it improved, since the results were not as negative as expected. Probably, they found that a good knowledge in chemistry would be useful to them, and perhaps the didactic methodology resulted interesting to them.

3.4 Student perceptions about the difficulty of each part

We inquired about the difficulty experienced by the students to understand each part of the subject (Table 4).

Table 4. Perceived difficulty of the different parts.

I have found easy to learn	*Mechanics*	*Agri - Food and Rural Affairs*	*Electric*	*Industrial Technologies*	*Chemical*
Theory	2.4	3.5	2.9	5.0	7.8
Problems	6.7	7.3	6.8	7.5	8.1
Laboratory	3.4	3.9	4.5	6.4	9.0

Solving numerical problems is the part that has been easier to assimilate by all Engineers, as they have facilities for calculation. This partly explains the large proportion of students who have passed the subject, as the final exam precisely consisted in this. They have some difficulties to understand, perform and interpret laboratory work (except IQ) as a good background on general chemistry is essential to work proficiently in the laboratory. The hardest activity has been to understand the theory, because of its intrinsic difficulty and the lack of previous knowledge. Considering the distribution by grades, IQ had least difficulties to pass the subject, which is due to its higher prior knowledge and interest in relation to chemistry.

4 CONCLUSIONS

The major barriers experienced by engineering students to pass the subject Chemistry were their initial lack of interest in the subject and their lack of background. In the first case, it can be solved if the teacher is able to convey the usefulness it can have on their career, teach the class in a pleasant way, explain the applications of chemistry (both casual life and industrial) within each topic, rather than through a specific theme and focus on content that may be of interest to them and easy to assimilate, instead on the most fundamental issues. For example, Redox and Principles of Organic could be expanded, while Atomic Structure reduced. We ought to introduce the theory through the numerical problems, rather than the other way round. On the other hand, we should encourage the students enrolling at zero courses, to set up free reinforcement programs, and pressure the administration to offer Chemistry as a compulsory subject in the High School and scientific / engineering Vocational Training. In its favor, it should be noted that engineers have a great capacity for work, which is what has allowed them to overcome the aforementioned drawbacks.

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