

Rosabel Roig-Vila (Ed.)

# Investigación e innovación en la Enseñanza Superior

Nuevos contextos,  
nuevas ideas

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*Investigación e innovación en la Enseñanza Superior. Nuevos contextos, nuevas ideas*

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NOTA EDITORIAL: Las opiniones y contenidos de los textos publicados en esta obra son de responsabilidad exclusiva de los autores.

# 1. Effects on the students results of organic chemistry subjects in two languages from a perspective of gender

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## ABSTRACT

In the field of Organic Chemistry, the students of the Degree in Chemistry at the University of Alicante can take subjects of the area either in Spanish or in English. The students' results have been analyzed to corroborate that the language used during the teaching-learning process does not influence the results. However, small differences have been observed in favor of the English groups due to the size of this teaching group. In general, students do not consider that a foreign language has been an obstacle when acquiring the competences of the corresponding subject. Students consider knowledge of specific terminology in English to be beneficial for their professional future. Despite this, the number of students taking the subjects in English is around a quarter of the total. Moreover, data has also been analyzed from a gender perspective, proving that there are no significant differences between the gender populations. There is a similarity in terms of results between both populations regardless of the subject, academic year or language teaching group.

**KEY WORDS:** English, Organic Chemistry, gender perspective, evaluation, student assessment.

## 1. INTRODUCTION

The internationalization and mobility of students within the European Space are considered as part of the main objectives in Higher Education. This should contribute to an improvement in the training of students, making it easier for them to spend time in international educational centers (Brooks, 2018). Therefore, carrying out actions that improve students' language skills is important and will have an impact on the improvement of the teaching process in the university (Morano-Foadi, 2005). Although different actions have been implemented to favor the mobility of academic members, such as all those integrated in the Erasmus+ plan, it is still necessary to continue with the development of the Higher Education internationalization (Altbach, Reisberg & Rumbley, 2010).

In the fields of science, technology, engineering, and mathematics (STEM), there is a gender gap, which is observed worldwide (Cheryan, Ziegler, Montoya & Jiang, 2017). Strikingly, it has been found that countries with high levels of gender equality, such as the Scandinavian, present larger STEM gaps in secondary and tertiary education (Ceci, Ginther, Kahn & Williams, 2014), constituting an educational-gender-equality paradox (Ceci *et al.*, 2014; Stoet & Geary, 2018). Thus, achieving the goal of parity in STEM fields is not just a matter of improving women science education and raising overall gender equality (Stoet & Geary, 2018).

In this context, we consider of interest to carry out an analysis of the results obtained by the students of different subjects (from the Organic Chemistry area) belonging to the Degree in Chemistry, with the objective of detecting possible differences between populations. It is envisaged to consider groups in which different languages (Spanish and English) have been employed during the teaching-learning process. In addition, the students' opinion is also considered of interest to better understand different aspects of the teaching process. Consequently, the analysis, from a gender point of view, of the results obtained by the students, as well as the students' assessment of the learning process will provide interesting information.

## **2. METHOD**

### **2.1. Description of the context and participants**

To place this study into context, different aspects should be commented. Firstly, the Organic Chemistry department of the University of Alicante has been carrying out educational research in different features of evaluation. More recently, our teachers have developed a variety of actions with the aim of improving the English language skills of students of the Degree in Chemistry. Our educational research group has followed up on these types of actions, therefore the experience acquired during these years allows us to continue with the analysis of them.

Considering our previous studies, the data has been collected from three compulsory subjects from the Degree in Chemistry: “*Advanced Organic Chemistry*” (AOC), “*Organic Chemistry*” (OC) and “*Structural Determination of Organic Compounds*” (SDOC). The subject OC (9 ECTS) belongs to the second year of the degree, while SDOC and AOC, which are 6 ECTS subjects, are taught during the third degree academic year. In the three subjects, the evaluation of knowledge and skills is obtained by a weighted average between Continuous Assessment (CA) activities (50%) and a Final Exam (FE, 50%). The data will be treated confidentially, eliminating all personal information. However, gender and language teaching group data will be handled for the subsequent analysis.

### **2.2. Instruments**

The students' assessments have been collected employing hardcopy surveys. Additionally, the Moodle platform has been used to obtain data related with the students' evaluation, marks and final score. The data have been managed, processed and analyzed using appropriate software (i.e. IBM SPSS v.24.0 and Microsoft Excel Professional Plus 2013).

### **2.3. Procedure**

Based on our experience, we planned and scheduled the different activities (i.e. preparation and deliver of the surveys, gathering and organizing data, obtaining and analyzing the results from these data) during the educational research group meetings.

Data have been collected from the students' results obtained in the evaluation activities of the different subjects. In addition, surveys have been prepared and delivered to students with the intention of obtaining information on aspects related to taking a subject in English and the gender perspective. Two types of surveys have been prepared, as shown in Table 1, for teaching groups in Spanish and for teaching groups in English. Both surveys present three identical questions (Q1-Q3) and two other questions (Q4 and Q5) depending on the language of the group.

**Table 1.** Surveys on the teaching of the subject for the groups taught in Spanish and English.

	Group taught in Spanish	Group taught in English
Q1	From your point of view, do you consider that the materials of the subject have been elaborated respecting an inclusive language of gender?  Answer: Yes – No – NR/DK	
Q2	Do you think that the knowledge of the specific chemical language in English can make it easier for you to enter the job market or gain access to other higher education?  Answer: Yes – No – NR/DK	
Q3	Did you know that you could obtain internal accreditation (University of Alicante), for the evaluation of the Final Project and access to mobility programs, passing subjects which are taught in English (12 ECTS for level B1 and 24 ECTS for level B2)?  Answer: Yes – No – NR/DK	
Q4	When you signed up for this course, did you know that one of the groups is taught in English?  Answer: Yes – No – NR/DK	Has the subject been more difficult for you to follow/study because it is taught in English?  Answer: Yes – No – NR/DK
Q5	Related to the reasons why you took the course in Spanish, select the option that best suits your case:  [A] My knowledge of English is not enough to take the subject in that language. [B] I have a sufficient level of English, but I prefer to take the subject in Spanish. [C] I already have English level B1 or B2, accredited by other entities different than University of Alicante. [D] I have already obtained enough credits in English, in the Degree in Chemistry at the University of Alicante, to get internal accreditation. [E] Other reasons (specify).	Related to the reasons why you took the course in English, select the option that best suits your case:  [A] To obtain level B1 or B2 for internal accreditation (University of Alicante). [B] I have sufficient knowledge of English, but I want to acquire specific language of the degree. [C] To improve the level of English, in general. [D] Other reasons (specify).

The analysis of the data and the results derived from it are presented and discussed below.

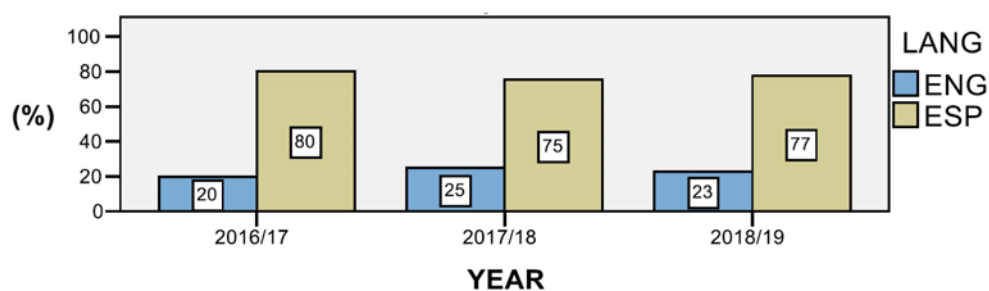
### 3. RESULTS

The number of students taking the three subjects (i.e. “*Advanced Organic Chemistry*”, “*Organic Chemistry*” and “*Structural Determination of Organic Compounds*”) during three academic years (from 2016/2017 to 2018/2019) is presented in Table 2. To have a better overview, the students are differentiated by gender. From this data, the amount of students choosing the group in English is 20-25% of the total number of students in the subject (Figure 1). Looking in more detail, the number of students in the subject “*Advanced Organic Chemistry*” has been increasing every year (Figure 2), being 41% of the students taking the subject in English during the present academic year 2018/2019. The percentage has doubled in only two years. On the contrary, the number of students taking in English the subject “*Organic Chemistry*”, which belongs to the second year of the degree, has been decreasing (Figure 2). The subject “*Structural Determination of Organic Compounds*” keeps the same percentage (*ca.* 25%) during the period considered.

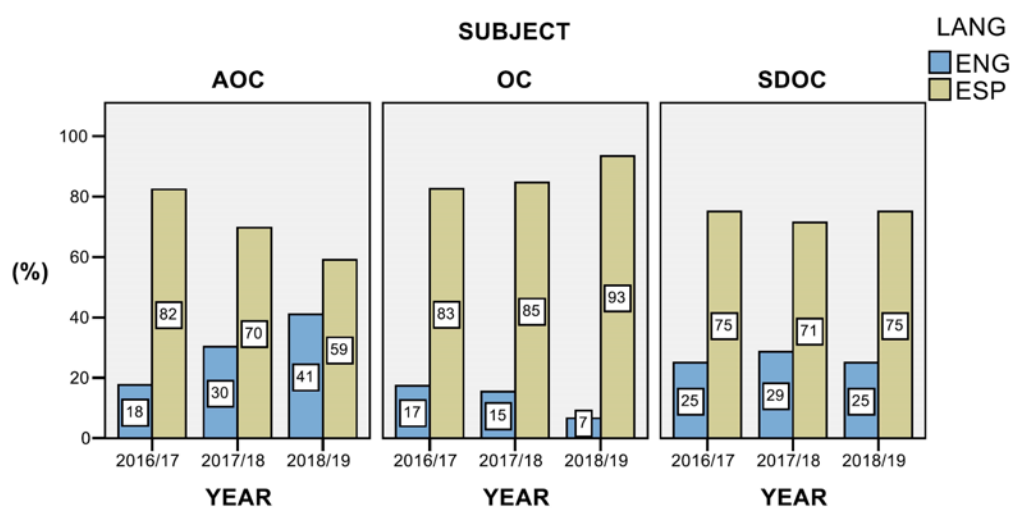
**Table 2.** Number of students in the groups of Spanish (ESP) and English (ENG) for the different subjects in the last three courses [F: female, M: male].

		AOC	OC	SDOC	Total Lang	Total
2016/2017	ESP	56 [31 F / 25 M]	57 [26 F / 31 M]	42 [21 F / 21 M]	155	193
	ENG	12 [6 F / 6 M]	12 [6 F / 6 M]	14 [9 F / 5 M]	38	
2017/2018	ESP	46 [26 F / 20 M]	55 [23 F / 32 M]	45 [26 F / 19 M]	146	194
	ENG	20 [10 F / 10 M]	10 [3 F / 7 M]	18 [9 F / 9 F]	48	
2018/2019	ESP	36 [11 F / 25 M]	71 [44 F / 27 M]	27 [11 F / 16 M]	134	173
	ENG	25 [14 F / 11 M]	5 [2 F / 3 M]	9 [3 F / 6 M]	39	

AOC: Advanced Organic Chemistry. OC: Organic Chemistry.  
SDOC: Structural Determination of Organic Compounds

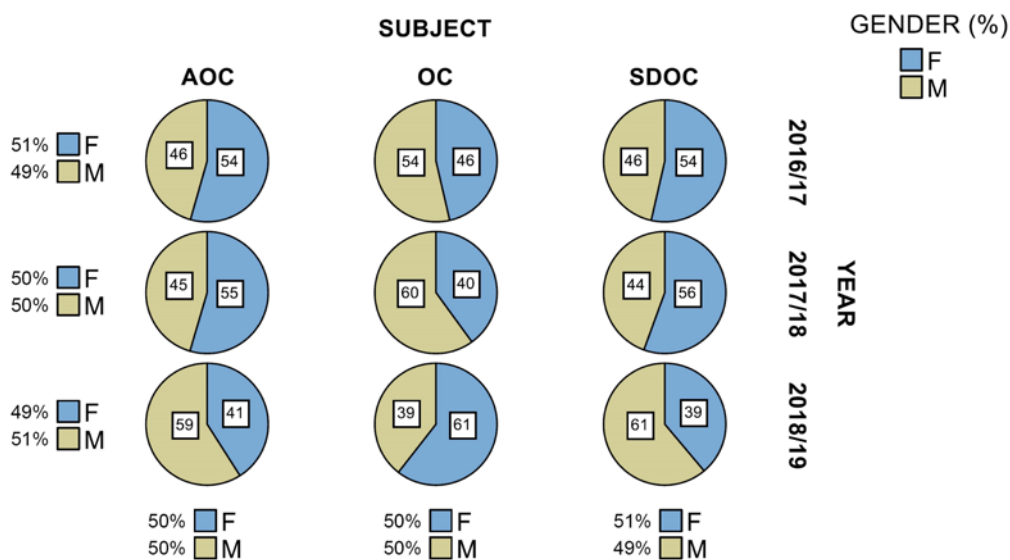


**Figure 1.** Percentage of students in the groups in English (ENG) and in Spanish (ESP) for each academic year.

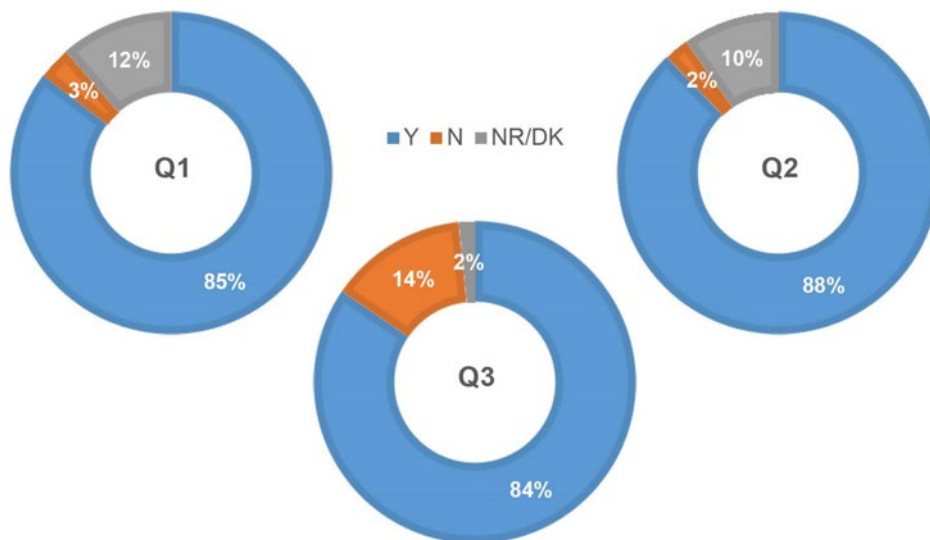


**Figure 2.** Percentage of students in the groups in English (ENG) and in Spanish (ESP) for the different subjects (AOC, OC and SDOC) in each academic year.

Considering the gender, the analysis of the number of students taking the subjects shows some alternation between both genders depending on the academic year and the subject. Interestingly, the overall analysis shows that, in the three-year period and for the three subjects considered, there is fifty-fifty ratio for female and male (Figure 3). It should be noted that considering the groups taught in Spanish during the three academic years the female/male ratio is 50/50, 51/49 and 49/51, while in the groups taught in English the ratio is slightly more variable, with values of 55/45, 46/54 and 49/51.



**Figure 3.** Percentage of students according to the Gender (F: Female, M: Male) for the different subjects (AOC, OC and SDOC) and the academic year.

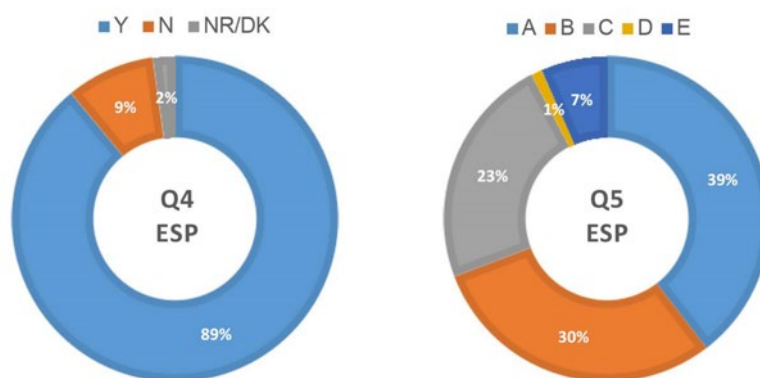


**Figure 4.** Results of questions Q1-Q3 in surveys for both groups (ENG and ESP).

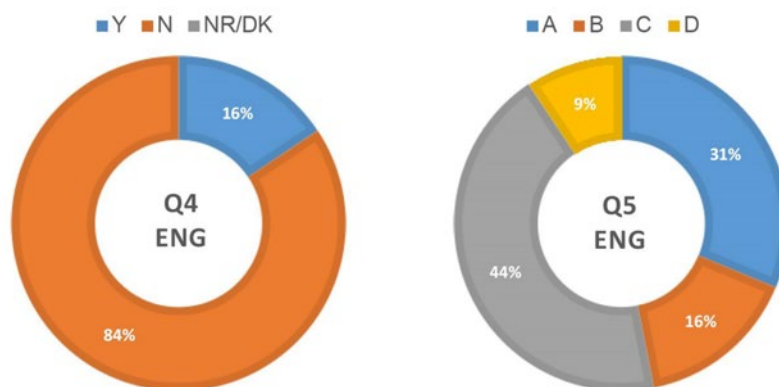
The results of the students' surveys, which were answered by 123 students, have also been analyzed. Among them, 91 students were from Spanish groups and 32 from English groups. Thus, the collected surveys represent a statistical sample that is in the average observed for the teaching groups, with a 25% from the total belonging to the English groups with respect to the total. The questions Q1-



Q3 are identical for both groups (Table 1), the analysis being represented in Figure 4. Remarkably, only 3% of the students considered that the materials of the subject have not been elaborated respecting an inclusive gender language (Figure 4, Q1). In question Q2, students were asked whether knowing specific English language would be beneficial for their professional future, with 88% agreeing (Figure 4, Q2). At this point, it is interesting to mention that this opinion is similar regardless of the students group. Thus, 91% of the students in the English groups and 87% of the ones in the Spanish groups think that knowing English is important for their career. Moreover, only 2% of them think that knowing English would not help them in finding a proper job (Figure 4, Q2), belonging all of them to the Spanish teaching groups. With regard to question Q3, a large majority of students (84%) stated that they were aware of the internal accreditation system for a foreign language after taking a number of credits in that language (Figure 4, Q3). This percentage has increased since last year, when only 70% knew of this internal accreditation system (Albert-Soriano *et al.*, 2018). To know the reasons of the students when choosing the teaching group, questions Q4 and Q5 were asked, being different for each group. The results for groups taught in Spanish are summarized in Figure 5 and the ones for English groups are in Figure 6.



**Figure 5.** Results of questions Q4 and Q5 in surveys for the groups taught in Spanish (ESP).



**Figure 6.** Results of questions Q4 and Q5 in surveys for the groups taught in English (ENG).

Almost 90% of the students in the groups taught in Spanish knew about the possibility of taking the subjects in English. This proportion is 85% if we considered only the students in second year, while is more than 97% considering the students in the third year. Among the reasons given for selecting the

Spanish group, only 39% of the students stated that they did not have enough knowledge of English to study the subject in that language. This amount increases to 43% for second-year students and drops to 32% for third-year students. The rest, in spite of their knowledge of English, prefer to choose the Spanish group, mainly for a better understanding of the contents.

The analysis of Q4 for the English teaching groups shows that 84% of the students consider that the language does not make more difficult to study the subjects (Figure 6, Q4). Related to the decision to choose the teaching group in English (Q5), the main given reason is to improve language skills, either in general (44%) or in specific science language (16%). In addition, almost a third intend to obtain internal language accreditation from the University of Alicante by taking subjects in English. The 10% of students give other reasons, mainly pointing out that English teaching groups are smaller.

**Table 3.** Statistics for all students female (F) and male (M) populations and T-test<sup>[a]</sup> values.

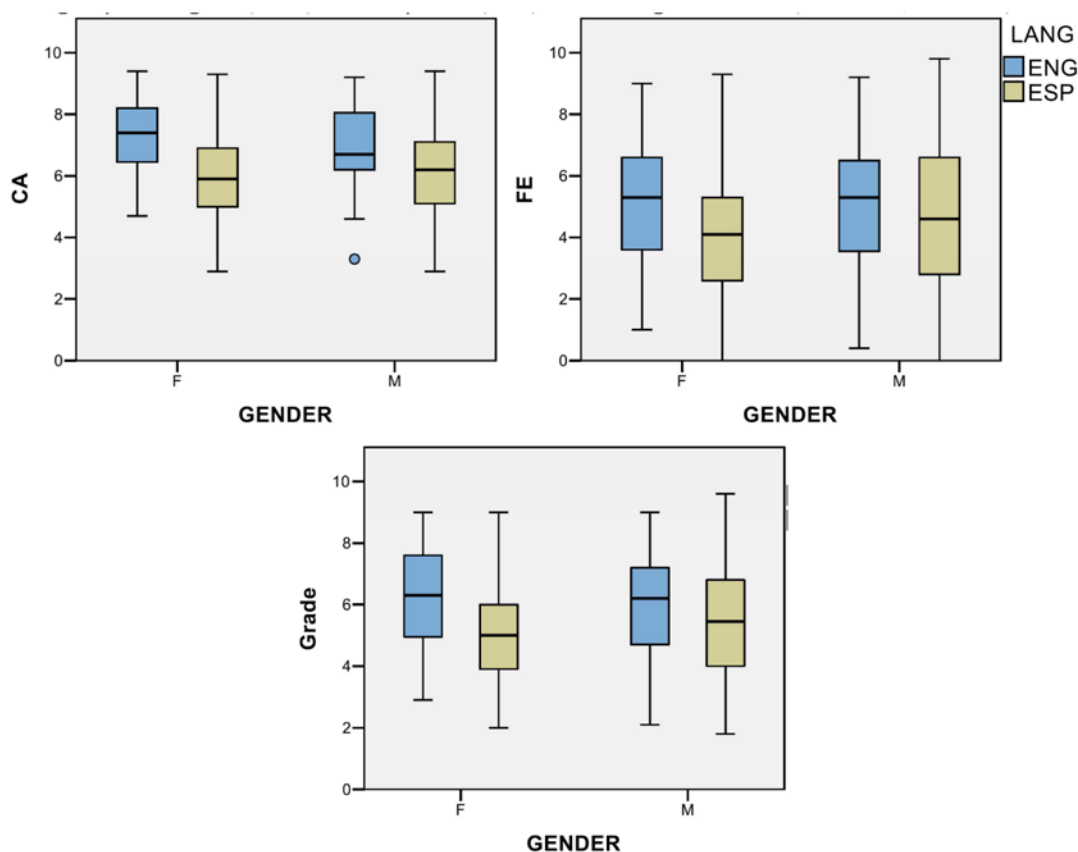
	Gender	N	Mean	Std. deviation	Std. Error Mean	Sig. (2-tailed)	Mean difference	Std. Error difference	95% Confidence Interval of the Difference	
									Lower	Upper
CA	F	220	6.25	1.441	0.097	0.461	-0.104	0.0142	-0.383	0.174
	M	193	6.35	1.427	0.102					
FE	F	220	4.37	2.183	0.147	0.134	-0.339	0.226	-0.782	0.105
	M	193	4.71	2.398	0.173					
Final Grade	F	220	5.30	1.640	0.111	0.169	-0.230	0.167	-0.558	0.098
	M	193	5.53	1.750	0.126					

[a] Test for equality means with equal variances assumed.

Academically, the analysis of the students' results has been taken to evaluate possible differences based on the gender. The study has been carried out using the results during the academic years 2016/2017 and 2017/2018 for the subject "*Advanced Organic Chemistry*" (AOC), and during the courses of 2016/2017, 2017/2018 and 2018/2019 for the subjects "*Organic Chemistry*" (OC) and "*Structural Determination of Organic Compounds*" (SDOC). The data considered have been the marks obtained by the students in the Continuous Assessment (CA) activities and in the Final Exam (FE), which result in their final Grade by fifty-fifty weighted average. Thus, data from 220 women and 193 men have been analyzed, and the statistics are given in Table 3. For the analysis, the few students who did not take the final examination were not considered. As expected, the statistical analysis (Table 3) revealed that there are no significant differences between the two populations (Female, Male) for a 95% confidence rate and assuming equal variances. There are less than 0.25 points (out of 10) mean difference for the final Grade between both student populations, although this difference is even lower (0.1 points out of 10) for the results corresponding to the Continuous Assessment marks (Table 3).

To continue the analysis, the boxplot of the different marks has been graphed, and both language groups for each gender have been analyzed separately, showing that the dispersions for both gender are comparable, regardless of language groups (Figure 7). The similarity of the analyzed data extends to the different rating items considered (i.e. Continuous Assessment, Final Exam and Grade). For the Final Exam mark dispersions, there is a slightly more significant difference between the female and

male populations belonging to the Spanish group (Figure 7), albeit there is not a statistical difference between them having comparable mean. In addition, the complete data has been explored based on linguistic groups (i.e., English and Spanish) presenting small differences (Table 4), and showing slightly different distributions. The differences are more relevant for the Continuous Assessment (Figure 7), although they are in favor of the English groups. This fact has been previously observed (Albert-Soriano *et al.*, 2017), being associated to the smaller size of the English groups.



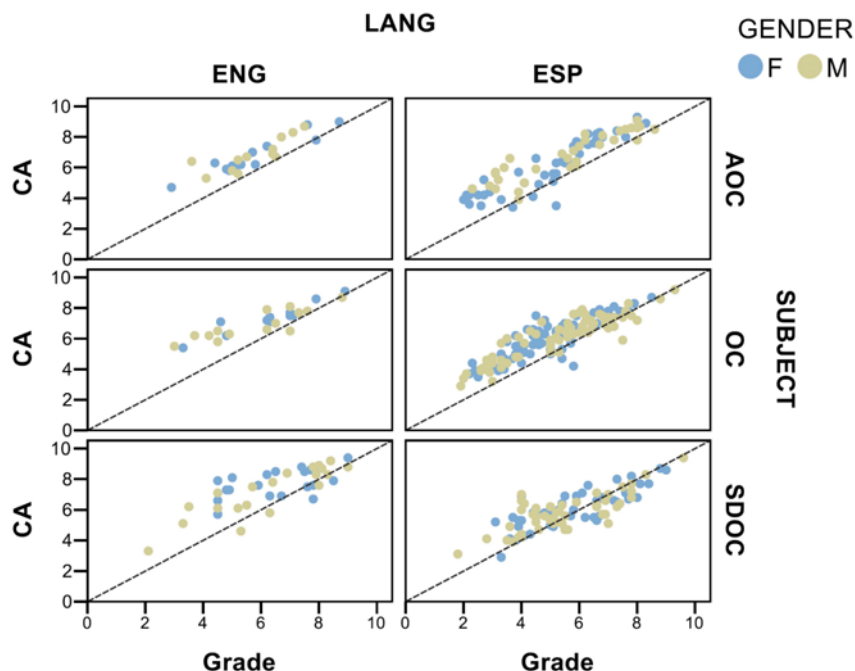
**Figure 7.** Boxplot of marks in the Continuous Assessment (CA), Final Exam (FE) and Grade for the groups in English (ENG) and in Spanish (ESP) considering the Gender (F: Female, M: Male).

**Table 4.** Statistics for all students in English (ENG) and Spanish (ESP) groups and T-test<sup>[a]</sup> values.

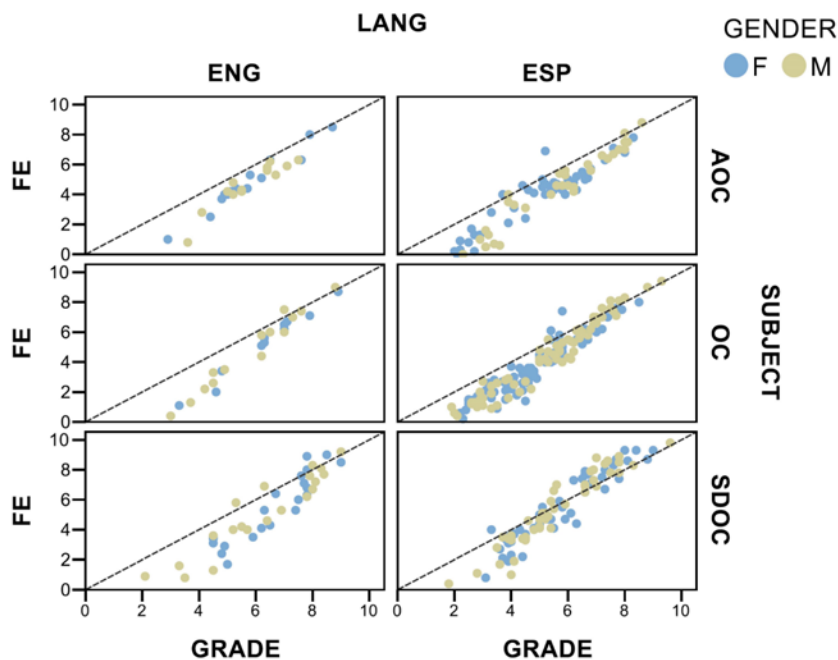
	Lang.	N	Mean	Std. deviation	Std. Error Mean	Sig. (2-tailed)	Mean difference	Std. Error difference	95% Confidence Interval of the Difference	
									Lower	Upper
CA	ENG	94	7.16	1.209	0.125	0.000	1.114	0.159	0.801	1.427
	ESP	319	6.05	1.398	0.078					
FE	ENG	94	5.05	2.222	0.229	0.012	0.674	0.267	0.149	1.199
	ESP	319	4.37	2.290	0.128					
Final Grade	ENG	94	6.12	1.589	0.164	0.000	0.914	0.194	0.533	1.295
	ESP	319	5.20	1.670	0.094					

[a] Test for equality means with equal variances assumed.

Next, the correlations between the marks in the final Grade and the ones in the Continuous Assessment have been considered for each subject comparing the female and male populations (Figure 8). As it has been observed previously (Trillo *et al.*, 2016), the students obtain higher marks in the Continuous Assessment activities than in their final Grade. In addition, there is a homogeneous distribution of the data for both genders, no significant difference being observed.



**Figure 8.** Correlation of final Grade with Continuous Assessment (CA) for the groups in English (ENG) and in Spanish (ESP) in the different subjects (AOC, OC and SDOC) considering the Gender (F: Female, M: Male).



**Figure 9.** Correlation of final Grade with Final Exam (FE) for the groups in English (ENG) and in Spanish (ESP) in the different subjects (AOC, OC and SDOC) considering the Gender (F: Female, M: Male).

Besides that, the comparison of the correlation between Final Exam marks and final Grade is depicted in Figure 9, no dissimilarities between the female and male populations being observed.

#### 4. DISCUSSION AND CONCLUSIONS

After three academic years offering the possibility of taking subjects from the Degree in Chemistry in a foreign language, such as English, the number of students choosing this option is approximately one quarter. However, the number of students in the English group increases for subjects in later Degree academic years. From the students' opinion, it can be settled that the main reason (32-43%) for not taking the subjects in English is the lack of appropriate language skills. However, there is a considerable number of language-trained students deciding not to take the English group because the language is considered as an additional trouble to the content of the degree. This is in contrast to the fact that 84% of students, in the English groups, feel that there is no additional difficulty due to language. Moreover, it is worthy to mention that in previous studies (Albert-Soriano *et al.*, 2017; Albert-Soriano *et al.*, 2018), it has been observed that, although it cannot be statistically validated, there are no significant differences between the groups taught in Spanish and English, students in the English groups obtaining slightly better marks, especially in Continuous Assessment (CA) activities. These differences are mainly attributed to the size of the teaching groups (Trillo *et al.*, 2016), the English groups being smaller.

Over the years, English has become the *lingua franca* for science due to the self-interest of scientists. In the case of chemistry, at least 85% of publications are made in English (Melitz, 2018). In this sense, the majority of the student surveyed (*ca.* 90%) consider that knowledge of English is important for their professional future. However, it is shocking that still 10% of the students of the Degree in Chemistry do not consider scientific English relevant for their future. In fact, chemistry students at the University of Alicante must certify a B1 level in English before graduating, although it seems that it would be necessary to raise students' awareness for language skills.

From a gender perspective, the study shows a fluctuation in the populations (female and male) depending on the academic year and the subject (Figure 3), but the overall shows equality. This point is in sharp contrast with the observed gender STEM gaps (Cheryan, *et al.*, 2017). Furthermore, a majority of the students asserted that the materials of the different subjects are elaborated respecting an inclusive language of gender.

At this point of the study, the analysis of the results obtained by the different gender populations becomes attention-grabbing. The number of people in both populations is not the same (220 females and 193 males), but the amounts are enough for the study to be meaningful. The statistical analysis proves that there are no significant differences between the marks obtained by women and men. This statement is valid for the Continuous Assessment activities, for the Final Exam, and evidently for the final Grade. In Continuous Assessment activities, there could be greater subjectivity as there is greater teacher-student interaction. Interestingly, the difference in mean values between the two populations for Continuous Assessment marks is only 1% (0.104 points out of 10). Therefore, from the point of view of the teachers involved in these subjects, this fact is very relevant and positive. Actually, there is a slightly larger difference in the Final Exam marks between both gender groups, although it is still only 3.4% (0.339 points out of 10). If we assume this equality, it should be expected that the percentages of students from each population who pass the subject are comparable. Thus, 48% of women and 49% of men pass the AOC subject (during the years 2016/2017 and 2017/2018), and in the case of SDOC there are 58% of both genders who pass the subject

(during the courses 2016/2017, 2017/2018 and 2018/2019). Finally, there is a small difference (43% of women and 46% of men) in the OC subject (during the courses 2016/2017, 2017/2018 and 2018/2019).

The dispersion of the marks of both gender populations are similar, as shown in Figure 7. Grouping the data based on the linguistic group still shows no differences between the two populations. As previously observed (Albert-Soriano *et al.*, 2017; Trillo *et al.*, 2016), there is a greater marks dispersion for the Final Exam than for Continuous Assessment. In addition, the mean values for Continuous Assessment are higher (in a range of 1.7-2.1 points) than for Final Exam. On the other hand, the distributions of the marks (Figures 8 and 9) follow the same patterns observed in previous studies (Albert-Soriano *et al.*, 2018), with small differences between the English and Spanish groups. In the present study, there are no appreciable differences between the marks for the genders populations, correlating Continuous Assessment and Final Exam marks with final Grade.

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