Rosana Satorre Cuerda (Ed.)

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Nuevos retos educativos en la enseñanza superior frente al desafío COVID-19

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La revisión de los trabajos se ha realizado de forma rigurosa, siguiendo el protocolo de revisión por pares.

2. Influence of the online teaching model in students' learning outcome in the Organic Chemistry subjects

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SUMMARY

The study herein presented has been developed using Organic Chemistry subjects belonging to the Chemistry (3 subjects) and the Chemical Engineering Degrees (1 subject) at the University of Alicante. No relevant differences in the subjects have been observed between the number of students of each gender during several academic years. From the investigations herein developed, it can be asserted that in general students do not have a great experience with the newly implemented remote-learning model since they feel that some important competences are not well acquired. In this regard, the students consider that their in person attendance is essential, especially in the laboratory and seminar and problem sessions. Consequently, most of them have chosen fully face-to-face or dual models as a hypothetical situation for the next future. Concerning the subject's outcome, the analysis reveals that students have obtained equal or superior marks in comparison with those of the pre-pandemic time.

KEY WORDS: online teaching, digital gap, organic chemistry, student assessment.

1. INTRODUCTION

The global sanitary crisis due to the current covid-19 pandemic situation, the subsequent lockdown established in March 2020, and the following restrictions that remain, have forced the University of Alicante (as well as many others) to implement a new teaching-learning model. In this model, a fully online teaching-learning process was applied in the last semester of the 2019-2020 course, and a dual-modality (online and face-to-face) was carried out during the 2020-2021 course. The sudden change in the teaching model could have affected the acquisition of competences and learning. Thus, factors such as digital competences of both students and teachers, digital gaps (Rodríguez-Abitia, 2020, 2020) (especially among students), and other problems clearly attributed to the lack of face-to-face interaction could have some impact on the acquisition of core competences in scientific and engineering studies.

Nowadays, society requires individuals with a strong background in the fields of science, technology, engineering, and mathematics (STEM) and with an equal gender balance in order to be competitive (Reinking & Martin, 2018). Therefore, the unavoidable implementation of the online teaching model during the pandemic resulting in a considerable reduction of some key experimental competences has a clear impact on the students' future professional situation.

2. METHOD

2.1. Description of the context and participants

The study herein described has been developed by an educational research group belonging to the Department of Organic Chemistry of the University of Alicante with in-depth experience in studies related to the evaluation process (Pastor *et al.*, 2016; Trillo *et al.*, 2016) and university learning-teaching activities (Albert-Soriano *et al*., 2018; Albert-Soriano *et al.*, 2019). The people enrolled in this educational research group teach several subjects belonging to the Degrees of Chemistry and Chemical Engineering, allowing the performance of an analysis of the possible differences in student outcomes of different subjects from those degrees by comparison of the pre-Covid period (where a face-to-face teaching-learning model was applied) with the previously mentioned current situation. The subjects "Structural Determination of Organic Compounds" (SDOC), "Organic Chemistry" (OC), and "Advanced Organic Chemistry" (AOC) have been selected from the Degree of Chemistry, and the subject "Applied Organic Chemistry" (APOC) has been considered from the Degree in Chemical Engineering (Iturbe-Omaeche, 2021; Iturbe-Omaeche, 2021). Furthermore, an overview of this implemented model with its pros and cons is also considered from the student's point of view (Vicerectorat d'Estudis, Qualitat i Llengües Universitat d'Alacant [VEQLUA], 2021). In addition, as a secondary purpose of this educational research study, the influence of the digital gap, which is still present in part of the student population, in their academic results has been evaluated (Rodríguez-Abitia, 2020).

2.2. Instruments

The Moodle platform has been used to obtain data related to students' evaluation marks and final scores, whilst the students' assessments have been collected using hardcopy surveys. The data has been managed, processed, and analyzed using the appropriate software (i.e. Excel - Microsoft Office Professional Plus 2016, IBM SPSS Statistics v27.0.1.0).

2.3. Procedure

The work developed during this study has been planned and scheduled by all the members of the educational research group through online meetings and the preparation and distribution of surveys were agreed upon by all the components. The collection and organization of data, the analysis, and interpretation of results has been carried out in an efficient and organized manner. The collected data has been confidentially treated, removing all personal information.

Students' results in the different subjects have provided quantitative data for this study. On the other hand, questionnaires provided to students have given access to information related to the online teaching-learning model during the pandemic time and possible digital-gap situations.

As shown in Table 1, the surveys presents eight questions. Q1 consists of a global rating of the online teaching-learning model, Q2 and Q3 are related to the general *pros* and *cons* detected by the students during this period. Q4 is aimed to identify possible digital gaps within the student population. Next, Q5 and Q6 try to figure out whether the students have experienced a lacking in the acquisition of some competences by t the implementation of the online model. Q7 is related to the online exams, tests, and evaluation activities. Finally, question Q8 proposes a hypothetical situation in which students can choose their ideal teaching-learning model.

Table 1. Surveys for the students in the different subjects.

	Question	Answer
Q1	Based on your own experience, rate the online teaching-learning model	0-10 (0 = very bad – 10 = excellent)
Q2	Indicate the possible *con*s of the online teaching-learning model	Lack in the acquisition of competences Poor interaction Student- Professor Professor's Digital Gap Student's Digital Gap Other (Specify)
Q3	Indicate the possible *pros* of the online teaching-learning model	Easiness/Convenience Objective Assessment Process Compatibility Studies/Work Studies Cost Reduction Other (Specify)
Q4	Have you experienced some technical difficulties following the online sessions? Specify	Yes – No – DK/NO
Q5	Do you think that you get the same acquisition of competences and knowledge in the online teaching-learning model as in the face-to-face teaching-learning model?	Yes – No – DK/NO
Q6	If it is the case, which part of the subject has been more affected by the online teaching-learning model?	Theory Seminars and Problems Lab Practices None of them
Q7	Do you think that you had any advantage due to the online assessment?	Yes – No – DK/NO
Q8	If you can choose the teaching-learning model, you would prefer…	Fully Online Fully Face-to-face Dual Model (Theory online, Lab and Problems Sessions face-to-face)

3. RESULTS

The students answering the surveys belong to three different subjects, two of them from the Chemistry Degree (OC from 2nd year and SDOC from 3rd year) and the third from Chemical Engineering Degree (APOC, 2nd year) trying to get as much heterogeneity as possible. In addition, they have been divided according to Gender (Female and Male) showing that there are no significant differences in terms of population between both (85 Females and 80 Males) which avoids a possible gender bias. The number of surveys analyzed, 165, is quite high and can be taken as representative.

As mentioned above the first question (Q1) consisted of a general rating of the online teaching model. From the results depicted in Figure 1 it can be concluded that, in general, the students have a good opinion about the model since a mean value ranging between 6 and 8 has been given regardless of the subject and the gender. Remarkably, within the 2nd year subjects, higher rating values were observed in the Female population. In addition, the lowest values and the major dispersion in the results were observed in SDOC (3rd-year students).

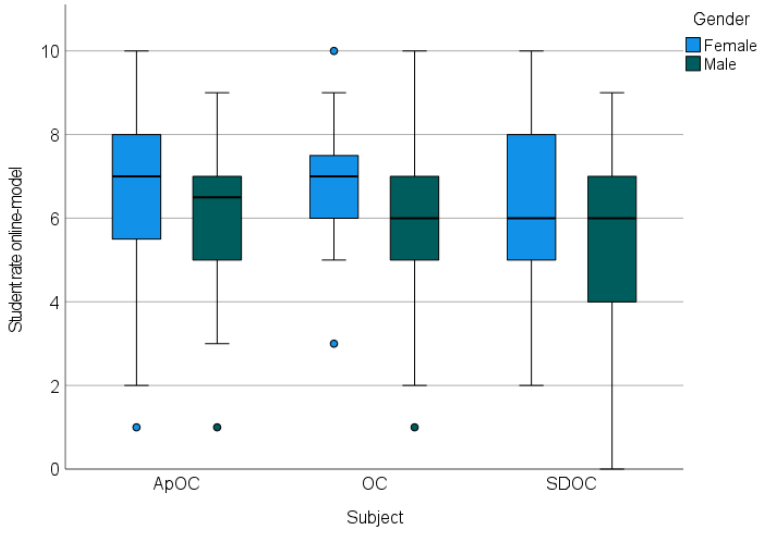


Figure 1. Boxplot of the students' rate (Q1) for the online teaching model according to the Gender (Female, Male) for the different subjects (ApOC, OC, and SDOC).

The next analysis consisted of pointing out the *pros and cons* of the online teaching model (Q2 and Q3). The main problems associated with the online teaching model (Figure 2) according to the student's answers are the poor student-teacher interaction and the lack of acquisition of some core competences. This last point will be discussed in more detail in subsequent questions. It is worth mentioning that some students point out the lack of digital competences from the teachers as an important drawback of the online model. However, only a few of them contemplated their own digital gap as a possible problem.

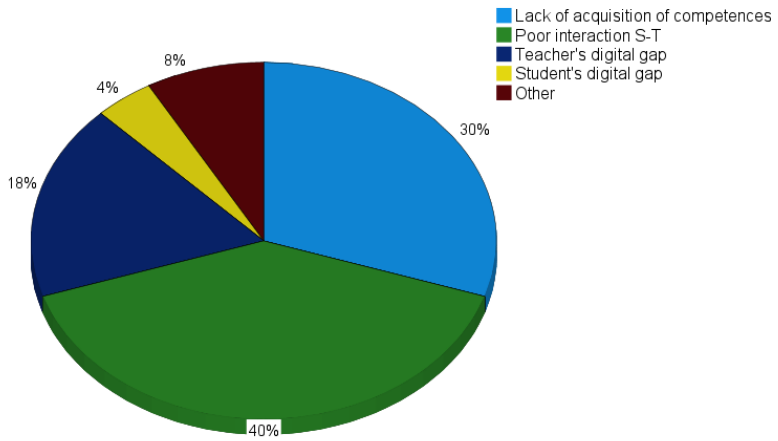


Figure 2. Question Q2 results (percentage) in the surveys (including subjects ApOC, OC, and SDOC).

On the other hand (Figure 3), the majority of the students highlighted the ease and convenience of the model from the fact of receiving teaching being at home. In addition, only 15% of the analyzed surveys pointed to a cost reduction as a possible advantage. It is also remarkable, and worthy of further analysis in the future, the percentage of students (18%) mentioning that online model could allow better compatibility between their studies and work. Surprisingly, only 2% of the surveyed students marked higher objectivity in the online evaluation process as an advantage of the model.

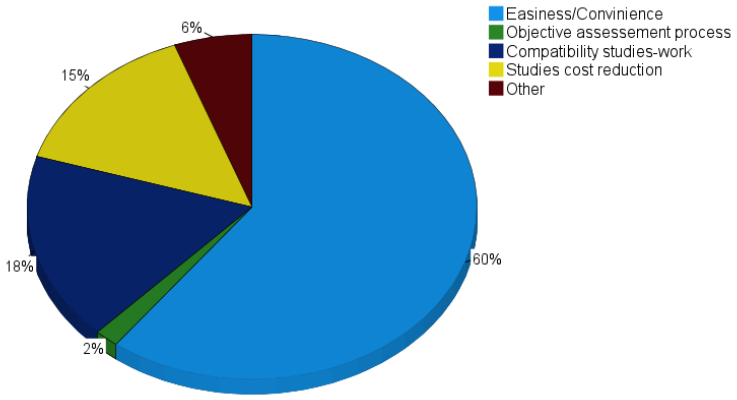


Figure 3. Question Q3 results (percentage) in the surveys (including subjects ApOC, OC, and SDOC).

Next, the analysis of the survey was intended to detect some student's digital gaps and was somehow related to Q2 in terms of possible disadvantages of the online model. Thus, to question 4 about possible technical difficulties (hardware, software, or Internet connection) which could have resulted in difficulties following the teaching sessions, a notable 29% answered affirmatively, specifying that the main problems were related to Internet connection. Although these problems could have indeed been punctual, the result is in clear contrast with the previously observed answer in Q2 about a student's digital gap.

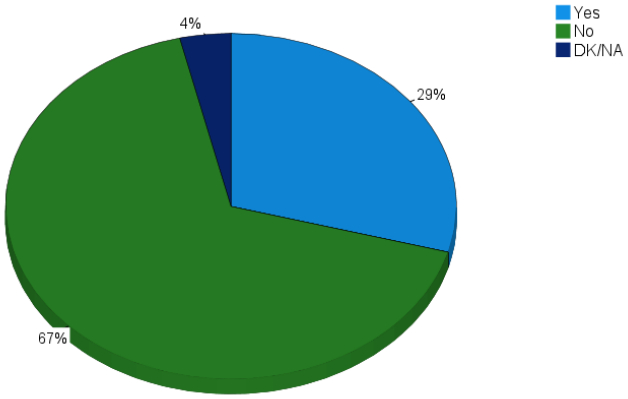


Figure 4. Question Q4 results (percentage) in the surveys (including subjects ApOC, OC, and SDOC).

Following the study, questions 5 and 6 (Figure 5) were related to the acquisition of core competences. From the analysis of the results of Q5, it can be asserted that an important number of students (62% of surveyed people) feel that with the online teaching model they did not acquire the same competences as with the face-to-face model. However, this percentage differs from the one obtained in Q2, where only 30% pointed to a lack in the acquisition of some competences (see Figure 2). In order to get more insights into this issue, Q6 was focused on those specific affected competences by the online model. As somehow expected, those competences related to laboratory practices being the most affected, followed by seminars and problems. Analysis of the answers according to Gender, revealed slight differences between females and males. Thus, whereas females indicate a major drawback in the laboratory practices, males barely remark a problem in a particular competence.

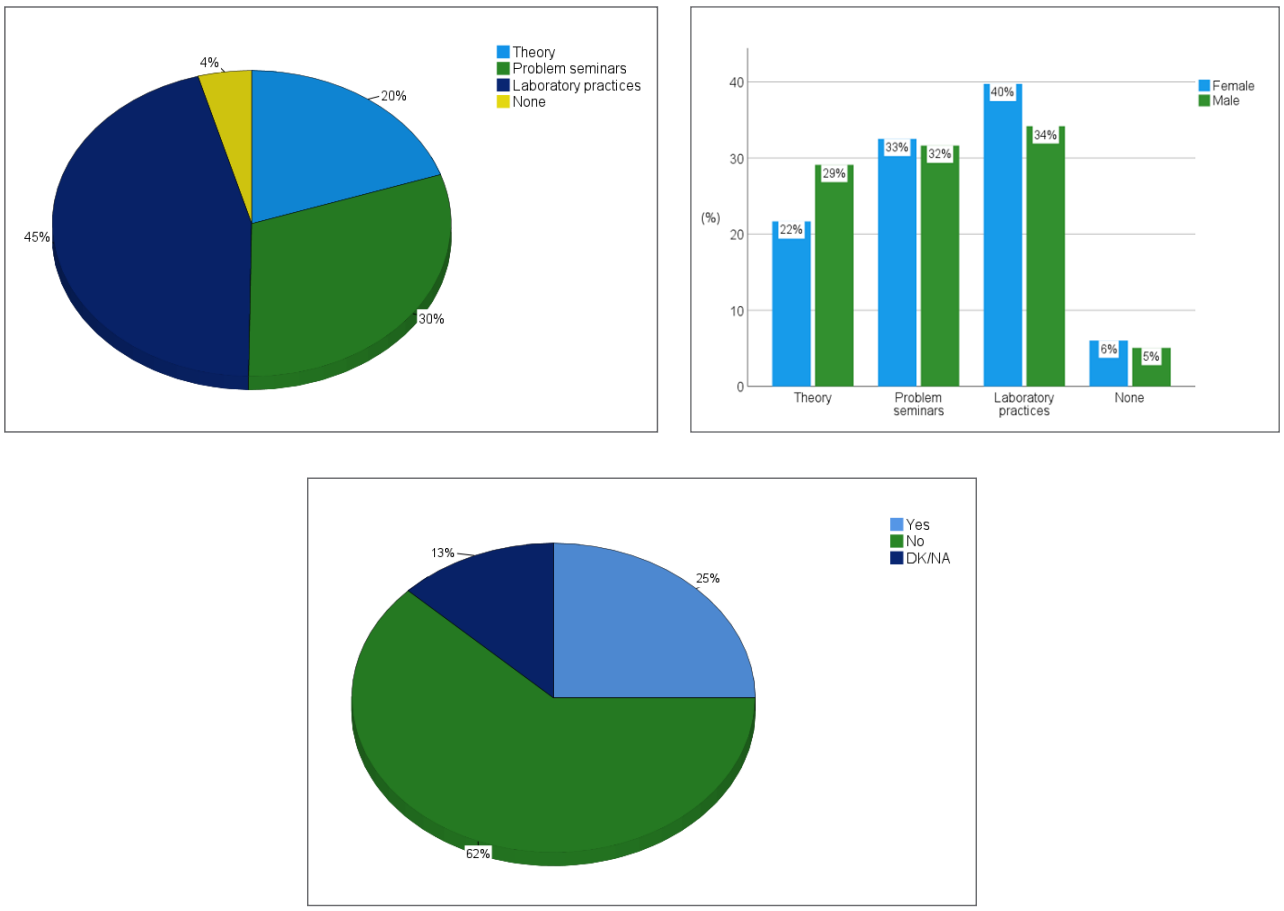
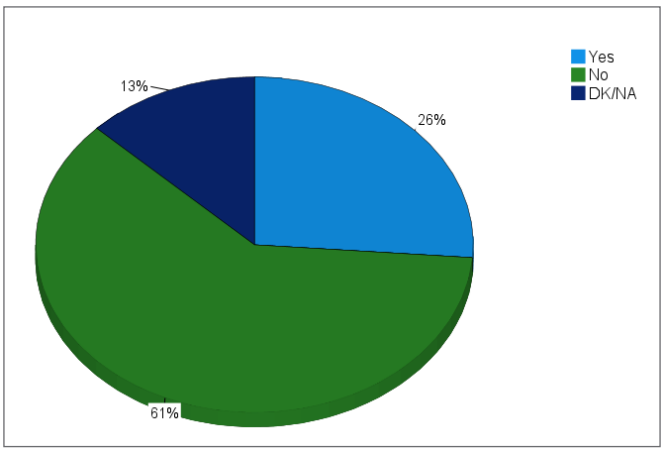


Figure 5. Questions Q5 and Q6 results (percentage) in the surveys (including subjects ApOC, OC, and SDOC) and Question Q6 results (percentage) according to the Gender (Female, Male).

Next, question (Q7) was aimed to retrieve some information about the student's assessment during the pandemic time. According to the answers (Figure 6), the majority of the students, regardless the Gender and Subject do not find any advantage in having an online evaluation. The results have been compared with the marks obtained by students in the second semester of course 2018-2019, where a face-to-face teaching model was employed and those obtained during the same period of 2019-2020 course, where the lockdown imposed a fully online model (Figure 7 and 8). The chosen subjects for the analysis were "Advanced Organic Chemistry (AOC)" from the 3rd year of Chemistry Degree and "Applied Organic Chemistry (APOC)" from the 2nd year of Chemical Engineering Grade. It is important to remark that despite the surveyed population is different from the students whose marks have been plotted, the comparison could give a general overview of the situation. It is convenient to stand out that the statistical analysis of the data during both academic years does not show any significant difference between the gender populations. Thus, the model teaching is not affecting differently to any of the genders. As depicted in the boxplots, in the case of AOC (Figure 7), a clear trend is observed being the student's marks significantly higher in course 2019-2020 (online assessment) in all the different areas analyzed (Continuous Assessment, Final Exam, and Final Grade) regardless the Gender evaluated.



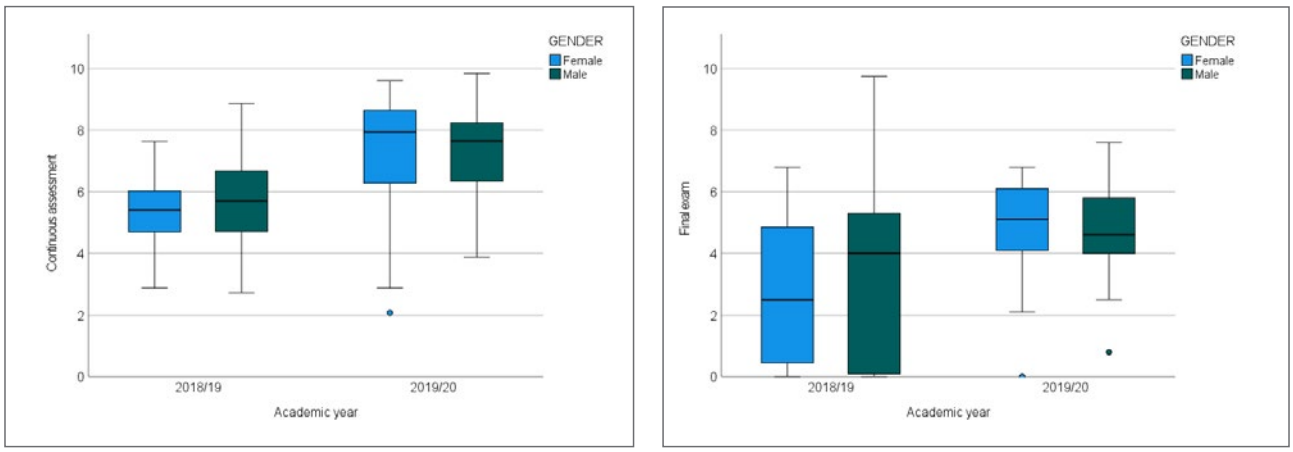


Figure 6. Question Q7 results (percentage) in the surveys (including subjects ApOC, OC, and SDOC).

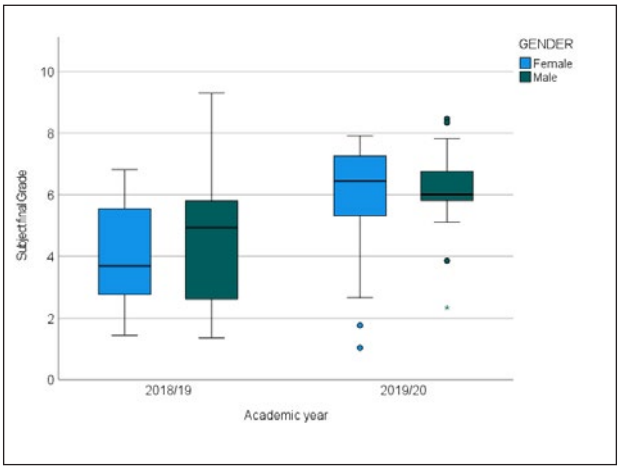


Figure 7. Boxplot of the students' marks in Continous Assessment, Final Exam, and Subject Final Grade for AOC subject according to the Gender (Female, Male).

Conversely, this trend was not observed when analyzing the results from ApOC in any of the assessment items plotted (Figure 8). As a curiosity, although it is not reflected within the graph, the ApOC students answered that online assessment represented an advantage for them in a higher percentage than the mean value (32% in front of 26%).

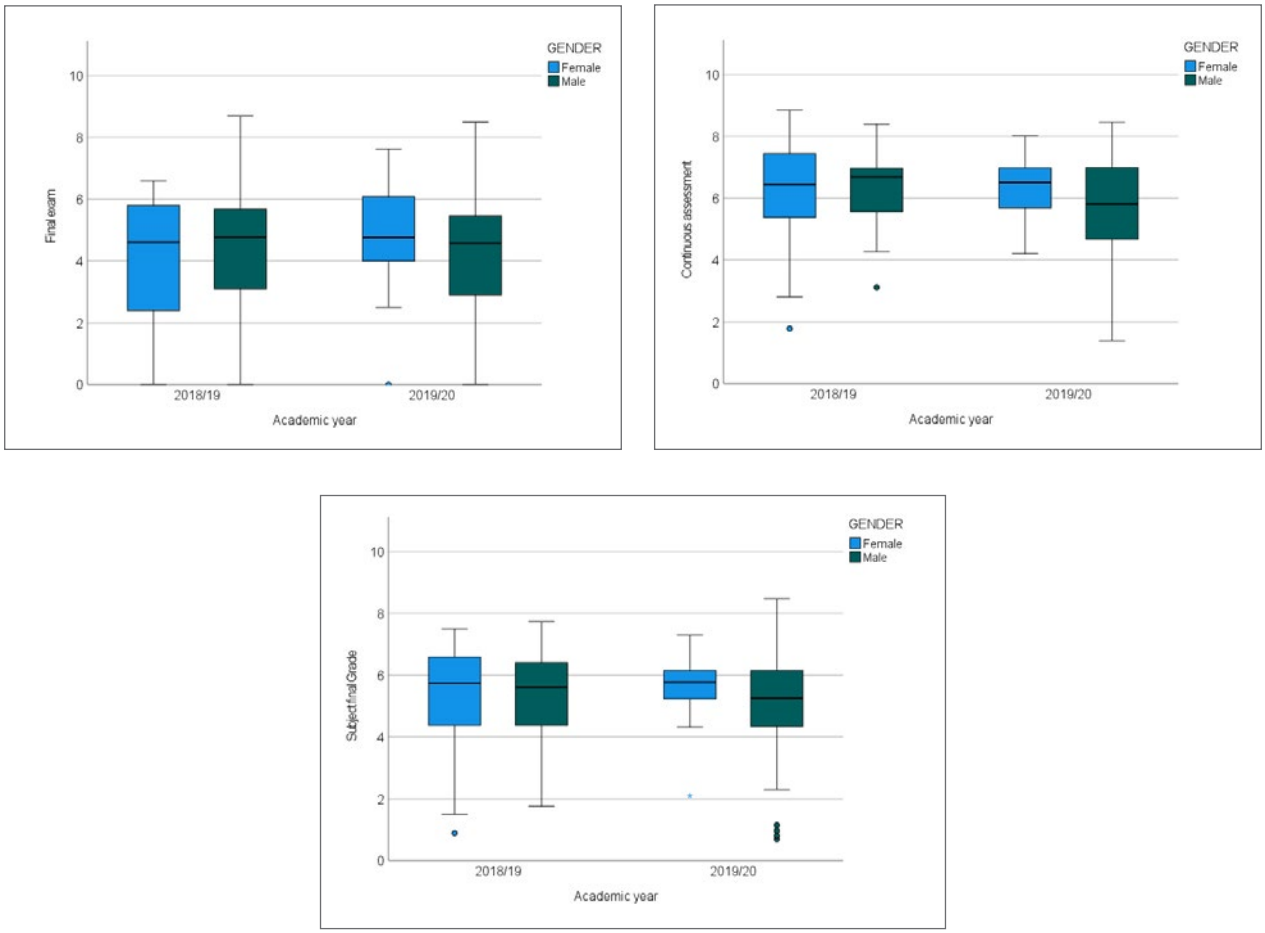


Figure 8. Boxplot of the students' marks in Continuous Assessment, Final Exam, and Subject Final Grade for ApOC subject according to the Gender (Female, Male).

Finally, in question 8 and according to the previous answers, students were asked to choose among different hypothetical scenarios of teaching modality. As depicted in Figure 9, more than half of the people surveyed preferred a dual teaching modality, in which theory content of the subject would be taught online, and problems seminars and laboratory sessions in a face-to-face modality. Notably, 37% of students selected traditional fully face-to-face teaching, and only 2% opted for the online modality.

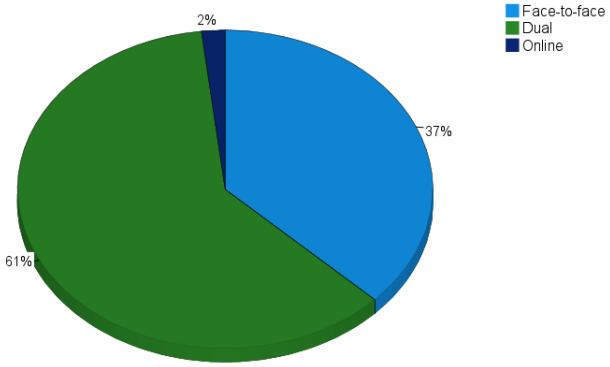


Figure 9. Question Q8 results (percentage) in the surveys (including subjects ApOC, OC, and SDOC).

4. DISCUSSION AND CONCLUSIONS

Firstly, it is important to say that the student profile is quite similar for both genders in the grades that have been considered in this study. There is no significant difference in gender populations, according to the data for all subjects. This could indicate that in the Chemistry and Chemical Engineering degrees of the University of Alicante there is no significant gender gap at this level contrariwise than the normal trend observed globally in STEM disciplines (Cheryan *et al.*, 2017). Moreover, the online teaching model does not differently influence any of the genders, with the results obtained by females and males being comparable.

The study herein presented has shown that in general students have quite a good opinion about the newly implemented online teaching model. This assumption was taken from the fact that a global mark ranging from 6 to 8 has been given to the model. A remarkable fact is that more experienced students (AOC subject, 3rd year of Chemistry Degree) have rated lower and with a wider dispersion the online model. Despite the apparent good acceptance of the online model, students have noticed some drawbacks; the main ones being the poor teacher-student interaction and the lack in the acquisition of some core competences. Among these competences, the surveyed students, particularly the female population, mainly complain about those related to laboratory practices, which are fundamental in applied degrees as the STEM disciplines are. In this regard, the results do not show a significant problem in terms of a possible digital gap from the students. However, almost a third of the population recognized punctual problems with an Internet connection.

On the other hand, the question about the possible advantages of the online model revealed that most of them (60%) pointed to the convenience and comfort of receiving the teaching being at home as the main one. However, only 15% of the students pointed to the studies' cost reduction as a possible advantage. Surprisingly, 18% of the population surveyed marked the compatibility of work/studies as an advantage. This relatively high percentage is quite intriguing since we do not know whether there is a correlation between this data and the number of students currently working. A closer insight needs to be performed in this regard and could be an issue studied in the future.

Concerning the evaluation process, the study reveals several interesting results. On one hand, and to our surprise, students do not find the online evaluation process more objective than when face-to-face evaluation is performed. In addition, only a minority (26%) answered that the online evaluation model was beneficial in comparison with the previous model. Nevertheless, the analysis and comparison of the marks obtained by students of the second semester 2019-2020, when the fully online model was implemented, with the previous course are not in concordance. Thus, in the subject AOC (3rd year of Chemistry Degree) a clear increase of the marks (up to 2 or 3 points higher) in each section was observed along with a narrower dispersion of such grades. In contrast, in the subject ApOC (2nd year of Engineering Degree) the results did not show a significant difference compared with previous years.

Finally, in a hypothetical scenario, the students were asked to choose different teaching modalities. As a result, the majority agreed (98%) in the fact that at least part of the subject must be performed in a face-to-face modality in order to avoid a lack in the acquisition of core competences. Among this population, 61% would rather prefer a dual teaching modality. That means, the theoretical contents would be taught fully online and the more practical contents of the subject, such as problems and seminar sessions, lab practices, etc. would be carried out in a face-to-face version.

In conclusion, the pandemic situation originated by the irruption of COVID-19 forced the Universities to implement an online teaching model without time for an adaptation period. Despite this sudden change and according to our analysis the implemented model was quite successful, at least

from the student's point of view. However, as clearly shown by the results of this study, the online model has major drawbacks that cannot be addressed easily, especially, those related to the acquisition of practical competences, which are essential for students of STEM disciplines. Another problem that can be difficult to solve, as it is shown in this study, is related to the online assessment. For that reason, according to the results of the analysis of the students' surveys, the implementation of a dual teaching model would be highly desirable, since it keeps the advantages of online teaching without detriment in the acquisition of competences and assessment process.

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