Teaching organic nomenclature for high-school students during COVID-19 pandemic

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ABSTRACT

In this work, we present the challenging experience of teaching organic nomenclature for high-school students during COVID-19 pandemic in Spain. Like in most places all over the world, the class-based teaching and learning was abruptly disrupted, and then all the methodologies had to be quickly adapted to a new remote format, mainly based on two virtual hubs in our case: MS Teams and EDpuzzle. Despite all the obstacles encountered, according to the students' scores and opinions, the learning process was eventually quite remarkable.

Keywords: Organic Chemistry, web-based learning, nomenclature

1. INTRODUCTION

Nomenclature has played a central role in Chemistry for ages. However, despite its importance, most students usually perceive it as difficult and demanding. Likewise, the lockdown caused by COVID-19 pandemic, which first started in China by the end of 2019 and was subsequently extended worldwide, only introduced additional difficulties due to the teaching disruption. Thus, all teachers and instructors of the countries affected had to quickly adapt their methodologies for this unforeseen situation.

In the case of Spain, the classes were abruptly suspended in March 2020, when the organic nomenclature module had to be taught in our school. After a single introductory session to nomenclature in the class, we continued teaching with a set of different remote activities, such as questionnaires, videos, etc. The purpose o fthis work is reporting that teaching experience, which was conducted within the Microsoft (MS) Teams and EDpuzzle frameworks. These two interactive platforms have permitted student's engagement with asynchronous and interactive tools, this permiting a a more active learning of organic nomenclature.

The description of such an extraordinary challenge is the main goal of this contributed talk.

2. METHODOLOGY

In this section, we report on the methodology that has been used in this work. First, we briefly describe the two virtual platforms that have been used (MS Teams and Edpuzzle). Next, we present the activities that the have been conducted by the students. Finally, we sum up with the student's assessment.

Internet tools used: MS Teams and EDpuzzle

The success of any e-learning process strongly relies on the right combination of synchronous and asynchronous tools[1]. For this purpose, we decided to conduct our web-based learning using MS Teams and EDpuzzle. The main advantages and drawbacks of these two internet hubs are listed in Table 1.

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On the one hand, MS Teams is an Office 365 product created in 2017 as a further development of MS Share Point. Its main functionality is the creation of collaborative (synchronous) work environments where users are able to chat, make calls and video-meetings, as well as to use any Office 365 app. This permits a peer-to-peer interaction between the students and the instructor, no matter where they are, nor what IT device is used. Likewise, MS Teams allows a computer supported collaborative learning, where knowledge can be shared, and tasks distributed after role assignment[2].

On the other hand, EDpuzzle[3] is an asynchronous tool that allows flipped classrooms as well as the development of self-regulated learning skills. This fact increases the engagement of the students as they participate actively in their own learning process, which increases their motivation. Furthermore, they can also set their own goals depending on their personal abilities and contexts. This methodology has not only been used for chemistry lessons[4] and other subjects such as Literature[5] and Biology[6], but also in university degrees[7].

Table 1. Main characteristics of MS Teams and EDpuzzle.

Pros and cons	MS Teams	EDpuzzle
Advantages	Efficient synchronous communication	Asynchronous sessions
	All in one place	Different possibilities (questions, notes, ...)
	Collaborative environment	Work on their own rhythm
	Separated groups feasible	Creation and sharing of audiovisual contents feasible
	Task assignments	Meticulous assignments
	Easy-to-access online classes	Immediate feedback
Disadvantages	Previous experience required	Free-version limitations
	Hard-to-control live meetings (undisciplined students)	Problems when answering (symbols, triple bonds…)
	Technical troubles (quality connection required)	Log in (username and password)

Activities performed by the students

The learning process was conducted by a combination of activities, some of which were individual while others were performed in groups of four students created by themselves. As can be seen in Figure 1, six distinct types of activities were done over the four weeks that lasted the learning process (being three of them of remote learning):

1. On-line teaching using MS Teams over the whole period. This tool enabled on-line sessions as well as a repository where documents could be uploaded (notes and exercises of the instructor, solved exercises of the students, etc.). In the 3rd week, it was used in two on-line lectures (L_1 and L_2).
2. Four questionnaires. Two of questionnaires were performed in the 0th (Q_1) and 3rd (Q_2) weeks of the module in order to assess the learning of hydrocarbons, while the other two (Q_3 and Q_4) had to be completed after two MS Teams sessions on Oxygen and Nitrogen compounds. The first questionnaire, which also included some general questions on the students features (age, academic record, previous knowledge of Chemistry…), was filled in the class, while the other three were completed individually using MS Forms. Some of the questions accounted for Science-Technology-Engineering-Mathematicss (STEM) aspects.

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3. Five videos on introduction to organic compounds (V_1); alkanes (V_2); alkenes, alkynes, rings, aromatics and halogenated derivatives (V_3); and two on oxygenated compounds (V_4 and V_5). The videos were recorded using Screencast-O-Matic and last 15 min. In order to assure to complete visualization of the videos on EDpuzzle, the students had to singly answer between four and ten multiple-choice or open-ended questions embedded in between.
4. Two collections of exercises (E_1 and E_2) that had to be solved in small groups, mainly focused on nomenclature but also containing some general questions on Chemistry, including a STEM dimension. The first collection of exercises (E_1) was used to analyze in more detail the success of the learning process after visualization of the videos V_1, V_2 and V_3, and automatically marked by Edpuzzle. The exercises E_2 were submitted to the instructor using MS Teams.
5. Two Kahoots! (K_1 and K_2), a gammification tool that was used individually to change the rhythm and increase students' motivation during the MS Teams theory sessions devoted to (i) oxygenated compounds, and (ii) isomery and Nitrogen compounds.

6. Satisfaction poll (SP) to find out the degree of motivation and commitment of the students. This poll was formed by 18 items and five open questions on general aspects of Chemistry (applications, importance, STEM), on the students' perception on their command on the studied concepts, as well as on the learning process itself (conducted activities, suitability of MS Teams and EDpuzzle as training channels, opinions and feelings on the acquired knowledge, etc.).

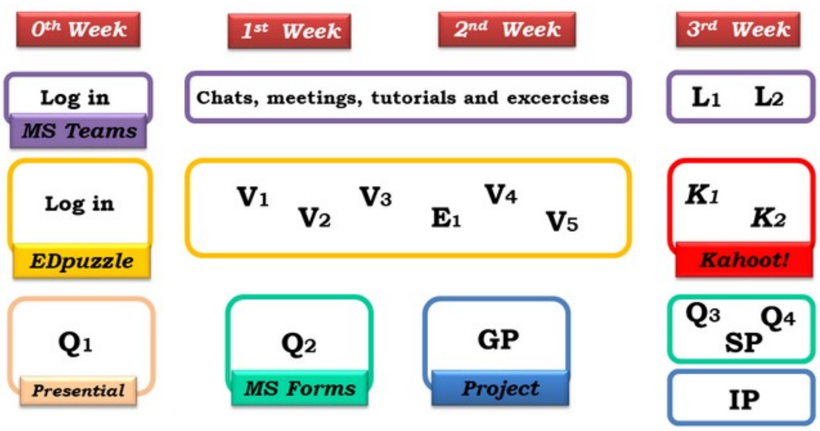

Figure 1. Activities performed over the four weeks devoted to organic nomenclature. 0^{th} week [redacted] introductory session, questionnaire Q_1, and the log in the virtual hubs. 1^{st} - 3^{rd} weeks (on-line MS-Teams sessions): 2 remote lectures (L_1, L_2), questionnaires Q_2, Q_3 and Q_4, videos V_1-V_5, exercises E_1 and E_2, Kahoots! K_1 and K_2, optional individual (IP) and group (GP) projects, and a final satisfaction poll (SP).

Furthermore, as discussed in more detail below, two additional voluntary projects were also included in our proposal:

1. Group project (GP), where the students had to report on five STEM aspects of Chemistry, such as presenting a Chemical compound of industrial interest or identifying a molecule present in our everyday lives.
2. Individual project (IP), where the students had to establish the environmental implications of (i) the halotropic forms of Carbon, (ii) the extraction of natural gas, or (iii) petrochemistry. Both activities were done in MS Word, and submitted to the instructor through the designated task in MS Teams. At the same time, the projects also enabled the study of those contents that could not be presented in the on-line sessions due to the lack of time.

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Assessment

The final assessment of the organic module was performed in a five-points scale as

$$0.35\left(0.30E_1+\frac{0.70}{5}\sum_{i=1}^{5}V_i\right)+0.30E_2+0.10\left(0.5Q_2+Q_3+Q_4\right)+0.10Behavior\left(+0.10GP\right)\left(+0.10IP\right) \tag{1}$$

Notice that the first collection of exercises (E_1) has been included in the global mark of the EDpuzzle videos. Recall that the last terms in parenthesis (projects) were optional.

3. CASE STUDY

The case study was formed by three groups of high school students of the Physics and Chemistry subject at the Colegio Maristas Chamberí, a private religious institution located at the center of Madrid (Spain). The initial number of students was 55, but two of them dropped off. As a consequence, the case study was eventually formed by 20 female and 33 men. Among them, 47 had already studied the previous term there. Most students were sixteen years old (equivalent to Junior students enrolled in the US Grade 11). Likewise, their families had middle to high incomes, and then all of them had the necessary IT devices for accessing the internet. Hence, equal opportunities to follow the remote learning was satisfied.

The learning of the organic nomenclature took place over four weeks between March and April three times a week in 50-min-long sessions. Except for the first introductory session, which was conducted physically in the class, the rest of the teaching was on-line.

4. RESULTS

Figure 2 shows the final scores of the students on organic nomenclature given by Equation 1 as a function of the previous records in a five-points scale. Note that all of them pass the module (only the final score of one student was smaller than 2.5 before doing the optional projects). Contrarily, almost one third of the students (12) had failed the previous modules. Moreover, most students decided to do the non-compulsory projects to get extra points. Consequently, their final scores increased on average 0.8 points. Let us also remark the large dispersion in the results of Figure 2. Actually, when performing linear regressions (superimposed as continuous lines), the correlation parameter R^2 has a modest value smaller than 0.3; then, caution must be taken when considering those linear fits. Still, their positive slopes demonstrate that, in general, those students who performed better in the previous didactic units also have here higher scores. Nevertheless, a few students with the highest previous scores perform here by contrast worse since their results lie below the dashed black line, which has slope one. Fortunately, the extra points obtained with the optional projects considerably solve this problem as the number of students that perform worse here than before reduces from 13 (32%) to solely 3 (8%).

Students' opinion

In this section, we summarize student's opinion on our Chemistry teaching-learning experience. For this purpose, an opinion's questionnaire at the end of the learning process has been performed. According to this pool, Chemistry was regarded, in general, as an important subject for most students. Actually, as inferred from inspection of Fig. 2, one out of five students thought that it is important in research. Moreover, 30% of the students pointed out its usefulness to improve our societies, while 25% remarked its significance to get a good job in the future. Finally, only one student (2% of the total) claimed that Chemistry was valuable to pass the module.

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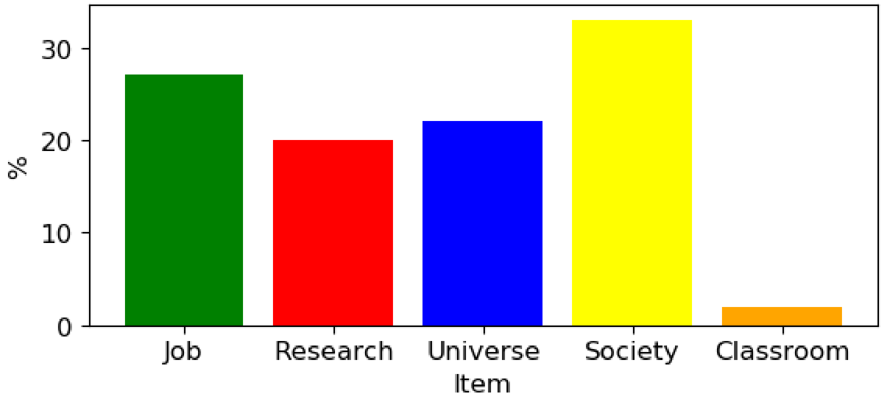

Figure 2. Students' answers when they were asked about the usefulness of Chemistry.

The students were also asked about the obstacles they have found in the remote learning process. As it can be seen in Fig. 3, most of them (22%) claimed that there was a variety of factors, such as the correct use of prefixes and suffixes, the different kinds of formulas, etc. 20% of the participants found quite complex the on-line methodologies, though some of them also claimed that "they would probably have had the same problems in a lecture-based teaching". Quite surprisingly, some native digitals do still have strong IT limitations. Another 20% regarded the abstract concepts and the memorization requirements the most demanding parts, while 17% found the functional groups and priorities according to the organic function the most difficult contents. Nomenclature in general (15%) or the common names set by the International Union of Pure and Applied Chemistry -IUPAC- (7%) were not as challenging.

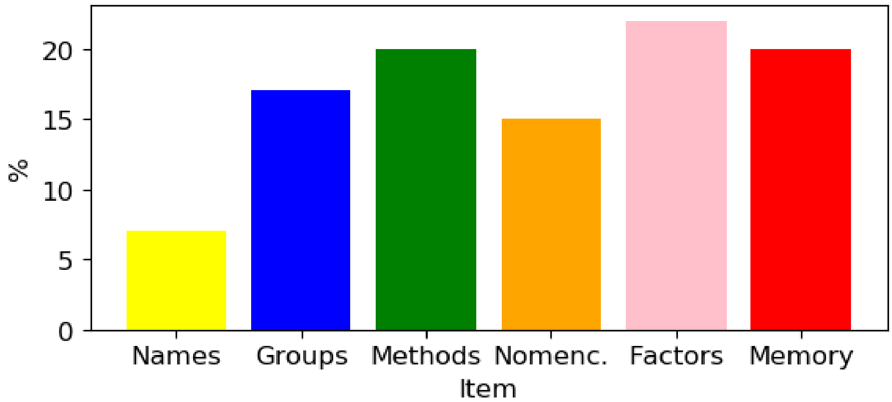

Figure 3. Setbacks encountered in the online learning of Organic Chemistry.

The students' perception on their commitment and engagement with the learning process was also analyzed in two poll questions. Each student had to evaluate to which extend did they think that their interest for Chemistry had increased "due to the activities performed and the methodology used" as well as whether "the effort and work had been enough to learn organic Chemistry". 30 (75%) and 34 (85%) students, respectively, gave more than 4 points in a 5-points scale to each of the previous claims, demonstrating a very good acceptance of the methodologies used. Unfortunately, we saw no correlation between the students answers to the previous questions and their final scores (taking and without taking into account the optional projects). A possible explanation for this fact is that the students have a better perception of their own work and commitment than what they actually are in reality.

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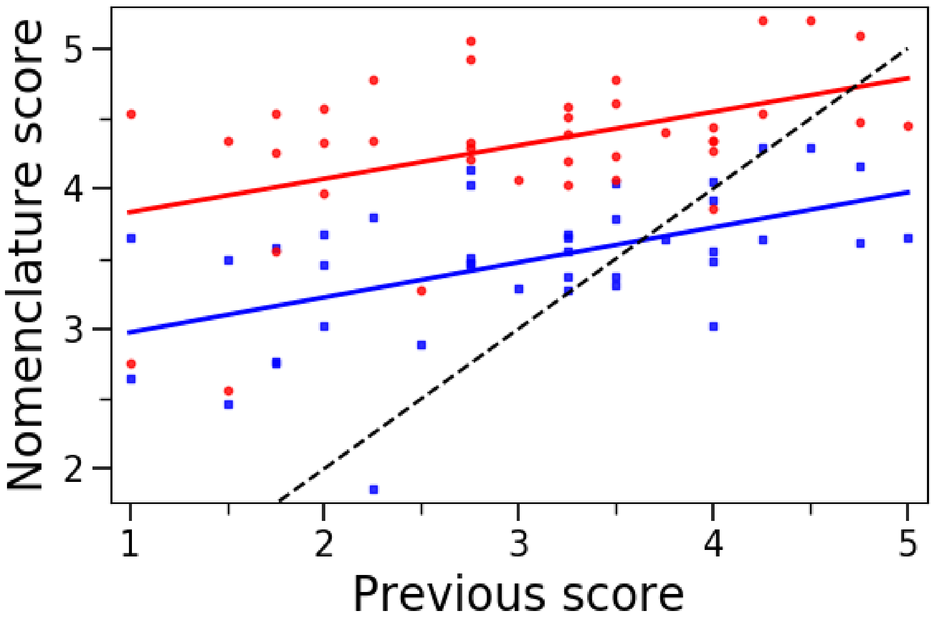

Figure 4. Final scores in the organic nomenclature part of the 40 students who answered the satisfaction poll as defined in Equation 1 as a function of the previous scores of the students in a five-points scale. The red circles (blue squares) show the scores with (without) the two optional projects. The continuous lines show linear fits to the data (least squares). The students whose scores lie above the dashed black line, which has slope one, perform better in nomenclature than in the previous didactic units.

5. DISCUSSION

Let us discuss some of the implications of our on-line nomenclature teaching. To begin with, recall that all our students were members of middle to high-income families. Consequently, all the participants had equal opportunities to follow the module from their places, though some of them had serious limitations with the use of electronic devices. Conversely, many students enrolled in other (high) schools, especially public, do not have such a privilege. Thus, special attention must be taken to this fact, as otherwise the teaching process will not pave the way towards a fairer society but boost the already existing differences between social classes.

Second, we found that, in general, the students enrolled in the bio-sanitary group had better assessments that those in the other two groups, associated with more technical studies. This difference is probably caused by their higher interest on the Chemical foundations of Biology.

Third, we have noticed that the set of activities performed lowered the academic record of those students who typically used to have the best performance. Unfortunately, we have no successful explanation for this unexpected fact. As a consequence, we suggest that any remote teaching should allow the most motivated students to get extra points by performing other activities, such as projects (like in our case), directed studies, exercises, etc.

Fourth, the on-line teaching that has been conducted has also allowed us to provide a STEM perspective into nomenclature, which is an excellent way to increase students' engagement. For example, to highlight the importance of Chemistry nowadays, the students were asked two questions related to COVID-19 pandemic (like which is the composition of the hygiene gels, or whether the virus SARS-CoV-2 is organic).

Fifth, due to the disruption of teaching we did not have time to develop more materials, but only for the use of hands-on simulations[7], virtual laboratories[8] or even the creation of videos or other multimedia resources by the students

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themselves[9, 10] would surely improve the learning process. Moreover, they would also enhance autonomous learning, which could also be used to learn those parts of the curriculum that could not be studied due to the small time frame.

Sixth, the use of an asynchronous tool such as EDpuzzle provides a lot of flexibility, as the studied contents (videos in most of our cases) can be consulted at any time.

Seventh, a fundamental limitation of this, and other similar, on-line methodologies is how can an adequate assessment be assured. For example, not all the members of a group have typically the same commitment; then, using a rubric, where students have to evaluate their own contributions as well as those of their colleagues, could be beneficial. Furthermore, the way the groups are formed can also have a dramatic impact on the development of the work. In the worst case, students could even have copied the answers to the individual questions.

6. CONCLUSIONS

In this work, the challenging experience of remotely teaching a module of organic nomenclature for high-school students during COVID-19 has been reported. For this purpose, several different activities have been combined using MS Teams and Edpuzzle as virtual hubs to allow remote teaching. Despite the lack of time to adapt the learning process to a new changing environment, our study shows that the performance of the students was quite good as they got better scores than previously. Nonetheless, several students with the best previous performance, needed the extra points of two optional projects to remain so successful.

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