FROM ONSITE TO REMOTE PRACTICAL LEARNING IN FUNDAMENTALS OF BIOTECHNOLOGY PROCESSES ENGINEERING I COURSE

M.L. Castelló, A. Heredia, J. Calvo-Lerma, A. Asensio-Grau, P.J. Fito

Food Technology Department. Universitat Politècnica de València (SPAIN)

Abstract

The COVID-19 pandemic has brought many changes in learning methodologies at all educational levels, including higher education. Under these circumstances, one of the most difficult challenges to face is to approach practical and laboratory learning at the university when students' attendance to the physical laboratory space is restricted. In the particular case of Bachelor's Degree in Biotechnology, future graduates are appealed to master many instrumental techniques related to this field. Therefore, the lack of onsite laboratory sessions where students observe, practice and experiment with materials and equipment to understand phenomena, either individually or in groups, might imply a detriment of the acquisition of the associated specific and soft skills. In order to minimize this negative impact in learning on COVID-19 pandemic, several initiatives have been carried out in order to adapt learning-teaching methodology from onsite to virtual-laboratory sessions. The aim of this contribution is to share, with other colleagues, the result of this experience in the context of the Fundamentals of Biotechnology Engineering I course at the Universitat Politècncia de València.

For that, the preparation of several supporting tools and resources were addressed. First, lecturers in the lab carried out all the steps of the experiments and recorded them for all the practical tasks in order to prepare short videos (5-6 min screencasts) in which experiments were entirely shown. To these videos, the pertinent related explanations to aims, materials and methods necessary to carry out experiments were incorporated where suitable, so that students had a guidance on how to proceed to get the experimental data of the practical task. Besides, pedagogical articles were prepared including the founding of the methodology and the explanation of the related theoretical concepts, along with the detailed description of the mathematical models and calculations required to achieve the desirable outcomes. Both, screencasts and articles, known in UPV as learning objects, take part of the UPV Online Teaching Plan. In order to assess students' achievements, they were asked to answer multiple choice/filling the gap questions tests delivered by UPV teaching platform PoliformaT. For that, they had two attempts and then they received feedback to contribute to their learning process. All this information was framed in the "Lessons" section of PoliformaT website of the subject to ease the course-monitoring. Furthermore, during the implementation of each practical task, lecturers and students were synchronically connected by means of Teams platform in the established timetable for each group. Thus, when attending to the lab was possible, lecturers showed in real time the procedure carried out in the lab by the students who physically attended the lab, and therefore, explanation was done in a more detailed way and students were able to ask their doubts directly to the lectures. If there was no possibility to attend the lab due to confinement, the practical tasks were also explained by Teams. In both cases, these meetings in teams were recorded to give the students the chance to visualize them as many times as they needed to understand all the procedure and calculus. Finally, students' perceptions about this experience was collected by means of a short questionnaire prepared using the Google forms tool.

Keywords: Learning objects, Screencast, Lessons, Practical skills, Microsoft Teams.

1 INTRODUCTION

The COVID-19 pandemic has fundamentally changed many aspects of our life, including the way of teaching at all educational levels. The emergency to move from completely on-site instruction to blended or online modality, forced taking rapid actions by teachers to adapt traditional onsite courses to the new scenario [1]. Under this emergency, teachers were fundamentally focused on transitioning contents to an online environment. They have been surprised by what is possible to do using virtual tools, but also experienced frustration with their limitations. Teachers faced multiple challenges to synchronously-or asynchronously- engage students in proactive and collaborative work, asking them to generate diverse results that could be shared in real time to enrich each other's ideas and receive feedback, and develop alternative assessments that require students to demonstrate their understanding in non-traditional ways [2].

Higher education was not foreign to this situation. In spring 2020, faculties and Engineering schools rushed to convert curriculum to an online environment, often by means of online tools to achieve all the learning objectives. Technical degrees, such as the engineering-based, are featured by relevant laboratory instruction in which students develop experimental skills, ability to work in teams and communicating effectively, learning from failure, and being responsible for their own results [3]. The laboratory environments may involve a blend of hands-on, computer-assisted and simulated tools. While hands-on experimentation was an essential part before the COVID-19 pandemic, blended and virtual laboratory sessions have become the new approach from the very beginning of COVID-19 pandemic because of the restrictions associated to the physical attendance at laboratories. In this context, the ability to maintain a focus on experimental skills in remote learning depends on the online resources available for both students and teachers, as well as the teaching approaches to ensure the acquisition of the specific and soft practical skills in remote lab courses. In consequence, it can be considered that pandemic also brought an opportunity for deep reflection about how we teach and how to ensure student learning under this new paradigm.

Concretely, bachelor degree's in Biotechnology aims at training professionals to be able to research, innovate, develop and improve processes, tools and biotechnological materials in the fields of health, food, agriculture, livestock and aquaculture, forestry production, energy, environment and industry [4]. It emphasises on practical skills that allow graduates gaining understanding of the principles and new generation techniques of applied biotechnology, in-person lab and computer sessions attendance, and practical tasks being an important part for skills achievement. In fact, around 40% of total ECTS of bachelor degree's in Biotechnology correspond to laboratory and computer sessions. Applied biotechnology skills and knowledge include research design and data analysis, handling biochemical and molecular techniques and equipments, critical thinking, problem solving and troubleshooting, scientific project management, legal and regulatory affairs, written and verbal technical communication, leadership and teamwork, and professional and ethical behaviour, among others. Due to the innovative nature of the biotechnology field, the curricula of biotechnological degrees and the teaching-learning methodologies involved are also constantly updated by the incorporation of new instrumental techniques and computer/simulated tools in the courses, many times supported by online platforms.

The Degree in Biotechnology is one of the most effort-demanding for the students in terms of the high level of the contents and the variety of disciplines they are required to learn. For this reason, students are highly motivated to achieve the challenging goals in the degree and committed to devote time and effort to obtain the highest evaluation results as possible. Despite of this fact, this is one of the most demanded university degrees in Valencia, being the cutoff mark for admission 13.18/14 in 2020 [4]. Because of the high demand to attend the Degree in Biotechnology, the UPV offers a total of 100 admission places per academic year (Fig. 1).

Figure 1. Information available in the webpage of UPV about the Bachelor's Degree in Biotechnology

On the other hand, Universitat Politècnica de València (UPV) has bet on e-learning education since 2000. In fact, UPV has consolidated as a key actor in European Higher education community regarding e-learning courses and massive open online courses (MOOC) and belongs to EDX platform. Besides, UPV has boosted the creation of the institutional repository of RiuNet joining the Berlin Declaration and Institutional Policy on Open Access. RiuNet is made up of different types of documents such as Objects of Learning (Polimedia, virtual labs and educational articles), theses, journal articles, maps, scholar works, creative works, institutional heritage, multimedia, teaching material, institutional production, electronic journals and conference proceedings [5]. UPV also ensures the online fluid teacher-students communication and academic tasks (teaching materials and academic works sharing, exams release, discussion (chats and forums), grades notification, …) by means of its suitable online educational platform "PoliformaT". Finally, UPV aware of the educational changes of the XXI century has been offering training courses on e-learning methodologies addressed to their teaching staff and promoted the development of online learning materials throughout its call DOCENCIA EN RED [6]. All these events have played a positive and determinant role to better manage the educational challenges during pandemic by UPV-teachers.

In this context, this contribution aims at describing the actions carried out to try to successfully adapt onsite laboratory sessions to virtual ones, together with teacher and students' perceptions about the contribution of the online methodologies to the practical skills acquisition in the context of "Bioprocess engineering I" course in the bachelor's degree in Biotechnology at the UPV.

2 METHODOLOGY

2.1 Context of the study

The implemented subject, Bioprocess engineering I, was framed in the first term of the second academic year within the Degree in Biotechnology at Universitat Politècnica de València (UPV). 107 students were enrolled in course 2020-2021 split into five different groups, Spanish being the working language in three of them, and Valencian, the regional co-official language in Valencia, in one group. The fifth group is named the "high academic performance" group, which is restricted to those students with the best academic records. The working language in this group is English.

2.2 Practical tasks in Bioprocess engineering I

Bioprocess engineering I, as most of the subjects imparted in the Biotechnology Degree, is divided into theoretical and practical lessons. Concretely, this subject accounts for 4.5 ECTS from which 1.5 ECTS correspond to practical learning goals (1 ECTS lab sessions + 0.5 ECTS processing data sessions in computing room). The theoretical lessons are devoted to the teaching of matter and energy balances as basic operational tools to solve engineering problems related to biotechnological processes. Then, the practical lessons are designed so that the students can set experimental conditions in which the acquired knowledge is applied to solve real situations by means of experimental data collection and calculations. So, generally practical tasks are programmed after the teaching of a theory unit has been implemented.

In this subject four practical tasks were established, the implementation of which was presented as 3 laboratory sessions (LS) and 2 processing data sessions (PDS) as shown in Table 1. All of the practical lessons had in common the following procedure: brief review of the specific theoretical contents that were needed to solve the practical task using the blackboard, experimental set-up and assembly of the stated problem/situation, experimental data collection, resolution of the calculations both theoretically and with experimental data. At the end of each practical lesson, an evaluation test was enabled within the subjects' intranet PoliformaT, so that students could complete it. To do so, students were allowed 45 minutes to complete the 10-question tests (including multiple choice, true/false, fill in the gap questions and results from calculations) and two opportunities. The result of the test was considered as the mark of each practical task. In addition, students had to attach to the evaluation test, before submitting, their own Excel file with all the calculations performed.

Table 1. Overview of the four practical tasks in the Bioprocess engineering I subject including the type of practical lesson (laboratory (LS) or processing data (PDS)), the addressed conceptual founding and a brief description of the practical activity.

Practical task	Type of lesson	Conceptual founding	Case of study
1	PDS	Matter balance with generation	Production of paracetamol
2	LS	Matter balance with accumulation	Dilution of salt concentration in a water tank with an input flow of pure water and an output flow
3	LS	Energy balance in the steady state	Heat loss reduction with different insulator materials in a heated agitated water tank
4	LS+PDS	Energy balance in the unsteady state	Heat diffusion prediction in a food can submerged in a water bath

2.3 Amendments to implement practical tasks in the COVID-19 pandemics

In a normal situation prior the irruption of the COVID-19 pandemics, each of the five groups of students attended the laboratory or the computer classroom and the implementation of the practical task was explained as above-described. However, in the present 2020/2021 academic year, several amendments had to be applied because of security and hygiene reasons, aimed at avoiding the transmission of the virus. As per COVID-19 protocol, the UPV established a maximum of 21 attendees to the on-site lessons in the laboratory (20 students + 1 lecturer). Additionally, a maximum of 3 students per on-site experimental setting was established. Therefore, as there were more than 20 students in some groups, and the in-person attendance to the practical lessons was not mandatory, a combined “on-site/online” modality to conduct the practical lessons was decided as the most appropriate approach. The adaptation to this new scenario was approached from different edges.

First, an on-line application form was set-up and uploaded to the intranet of the subject, so that students indicated their willingness or availability to attend the practical lessons on-site, and thus exceeding of the laboratory seating capacity could be avoided. In addition, when students indicated they were attending the practical task on-site, a signed informed-consent accepting the security conditions had to be submitted as well. For those students attending the practical task in the laboratory, an attendance registration was recorded.

Second, as some students would follow the practical task remotely in real time, the Microsoft Teams® platform was selected. The practical tasks were programmed in the Teams® calendar so that students preferring to attend the lesson remotely could join it. The students attending on-site were asked to bring their laptops to the laboratory for the calculations’ resolution afterwards. The laboratories counted on the necessary equipment to allow for this type of methodology, including a portable video-camera connected to the computer of the professor. In practical terms, the camera was located in front of the blackboard in the laboratory so that both students connected on-line and those on-site attending could follow the initial explanation simultaneously. Students following the lesson remotely had their microphones enabled, allowing them to raise questions or doubts. Once the initial explanation was completed the camera was turned so that students from home could see the implementation of the experiment. Then, once the experimental data was collected, the “share screen” option within Teams® was selected in the professors’ computer and the resolution of the problem with calculation sheets was performed. The whole session was recorded and stored in the Teams® repository in case students who could not follow the session in real time could do it at any other moment. As for the PDS, there was no need to on-site attend the computer classroom, so the two PDS were conducted entirely via Teams®. The evaluation tests were used as the assessment tool in the same way as in a normal situation, i.e., no changes in this regard were implemented.

Third, in order to skip/minimize the vicissitudes inherent to the security measures against the pandemics, several complementary materials and resources were created, with the aim of achieving a smooth implementation of the practical tasks and to promote a meaningful learning. The following section provides full details.

2.4 Specifically-developed materials and resources

In addition to the use of Microsoft Teams® as a vehicular tool to implement the practical lessons, different types of specific contents were developed to support both, the preparation of the student before the practical lesson and the resolution of the calculations. To make the learning experience more appealing and offer a more guided process to the student, all the resources were uploaded to "Lessons". This is an online space where a step-wise approach can be designed and how to use the resources can be explained to the student inside the PoliformaT platform, including a section per practical task. Fig. 2 provides an example. Students were notified some days before the practical task that the resources along with the roadmap on how to use them were available.

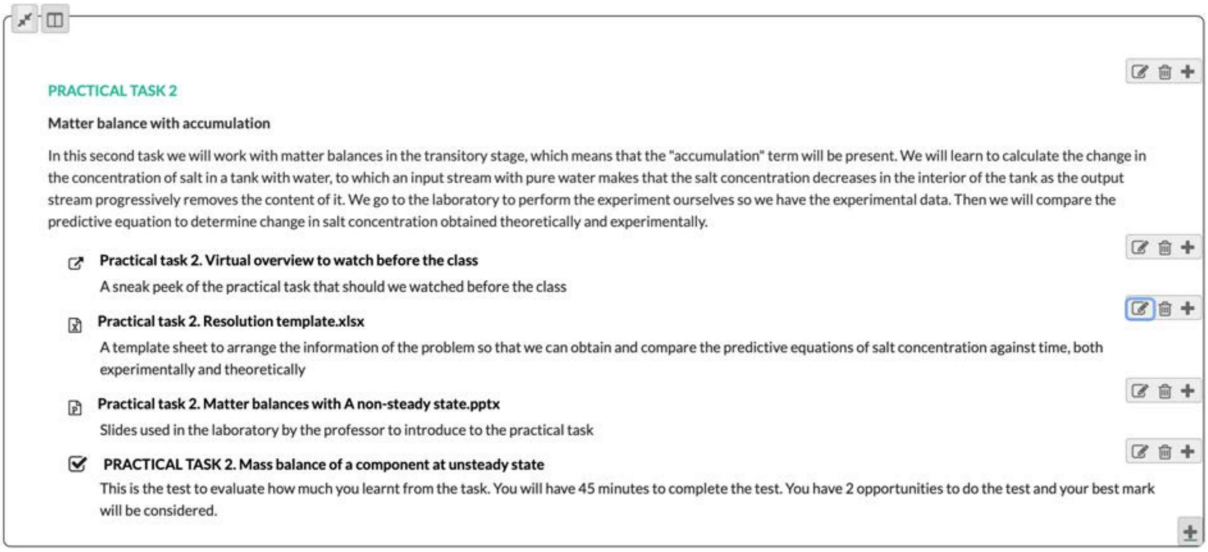

Figure 2. Screenshot of the "Lessons" space where students could find the different materials and resources to support the implementation and resolution of the practical tasks along with the roadmap explanations on how to properly use them. Example of the content in "Practical task 2"

Three different types of materials and resources were created (Fig. 3): **screencasts**, **pedagogical articles** and **calculation sheet templates**. The two first were designed as supporting materials to go through before the practical task, and the calculation sheet template was used during the last part of the session to solve the stated problems, or in the case of "practical task 4", a whole extra PDS was devoted for this purpose, as more complex calculations entailed a longer resolution process.

- **Screencasts** consisted of Power-point presentation-based videos, including the theoretical basis, the materials needed, the experimental set-up and the templates to collect the experimental data, with a recorded voice-explanation by the professor in the background and the support of a pointer. The screencasts also included, as part of the content, tailor-made videos in the laboratory showing the key aspects of the experimental process. These videos had been recorded by the professors of the subject before the start of the academic year in anticipation of the possible pandemic's restrictions.
- **Pedagogical articles** are written documents in which a specific problem related to a theoretical content is presented, with similar characteristics to the problem proposed to students in the practical task. This type of paper follows a step-wise resolution of the problem, including calculations and references to the theoretical basis.
- **Calculation sheet templates** are based on Excel files. To make the resolution of the problems clear and ordered, students are given these pre-set templates with tables to fill in the experimental data, the screenshots with the needed equations extracted from laws and theorems (also available in the pedagogical articles) are pasted where appropriate, the space for students to plot the experimental data to obtain the experimental equations are delimited, and the specific data, given by the problem in order to solve it, are provided too. When students submit the evaluation test, the calculation sheet has to be attached to it as a means of confirmation that the understanding of the practical task was achieved.

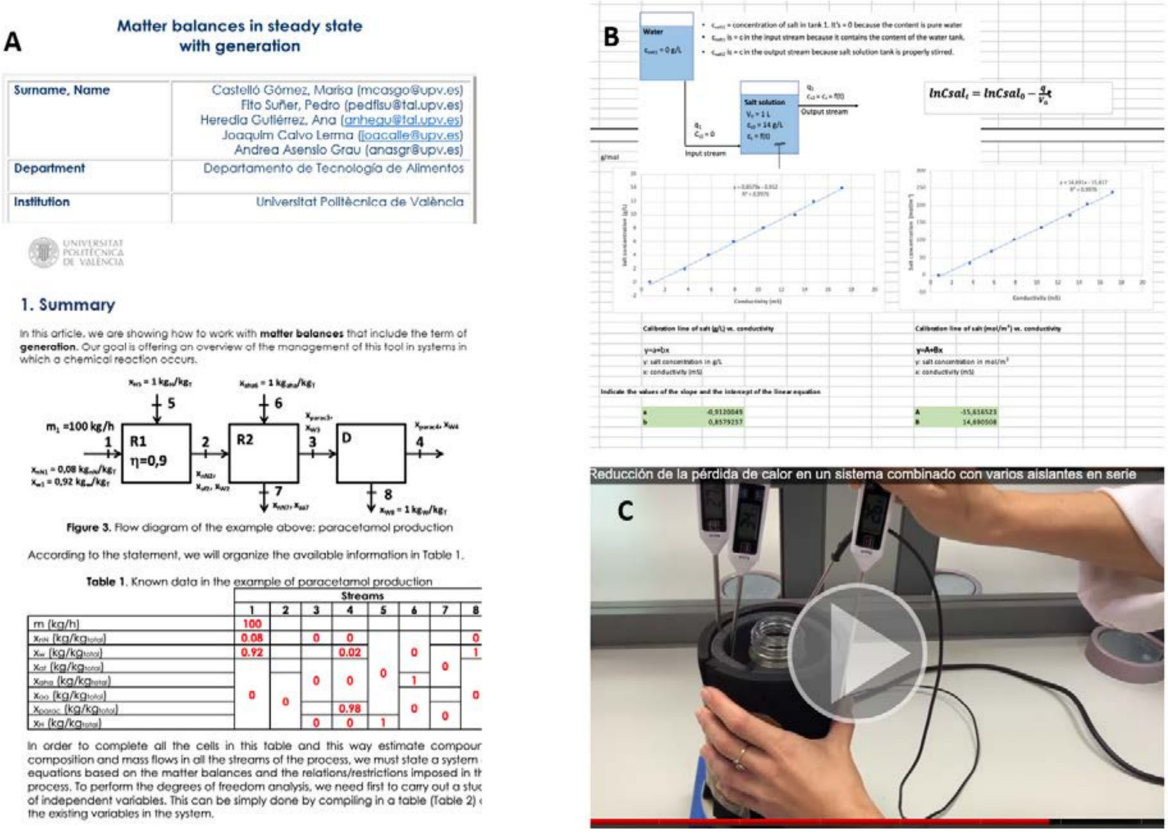

Figure 3. Sneak-peek of the three different materials and resources: A) pedagogical article, B) Excel template and C) Screencast

2.5 Opinion survey to validate the newly developed methodology

Once all the practical tasks had been conducted, students were asked to complete an online survey to gather their feedback regarding the new combined online/onsite methodology for the practical tasks. The Google Forms tool was selected for such purpose, which included the following 3 queries:

- What tools have been most useful to you for learning the theoretical-practical contents?
- In the context of learning practical content at IPBI, select the option that best suits your opinion regarding the advantages of using the PoliformaT Lessons tool
- The Teams platform has allowed you to follow the practical tasks in a way equivalent to face-to-face teaching

3 RESULTS

In this section, an analysis of the evolution of the assessment in the last for years is performed. Besides, the results of the students' opinion evaluation are also presented.

3.1 Assessment of the practical tasks in the last years

As shown in Fig. 4, the academic performance of the students has improved in the last academic year despite the lack of physical presence in the laboratories or computer rooms. In this sense, the effort made by lectures of this course, generating screencasts, pedagogical guidelines and recording of the classes, has contributed to improve the establishment of theoretical-practical knowledge. It is also remarkable that in the 2017-18 academic course the students' skill in practical tasks were assessed only by reports, showing that the grades were significantly lower than when tests composed by theoretical and practical questions were used from 2018-19 academic year onwards. In any case, these students have a very high-level performance.

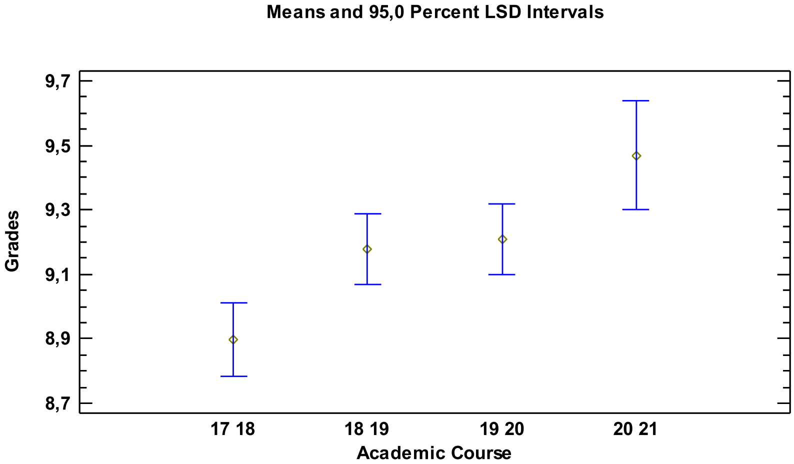

Figure 4. Average grades of the practical tasks of the Bioprocesses Engineering I course in the last four academic years.

3.2 Results of the students' perception of the practical tasks

To the question: **What tools have been most useful to you for learning the theoretical-practical contents?** Students answered that the Excel templates were their first choice, followed by the short videos or screencast and then by the teaching pedagogical articles with the written explanation of the practical tasks (Fig. 5).

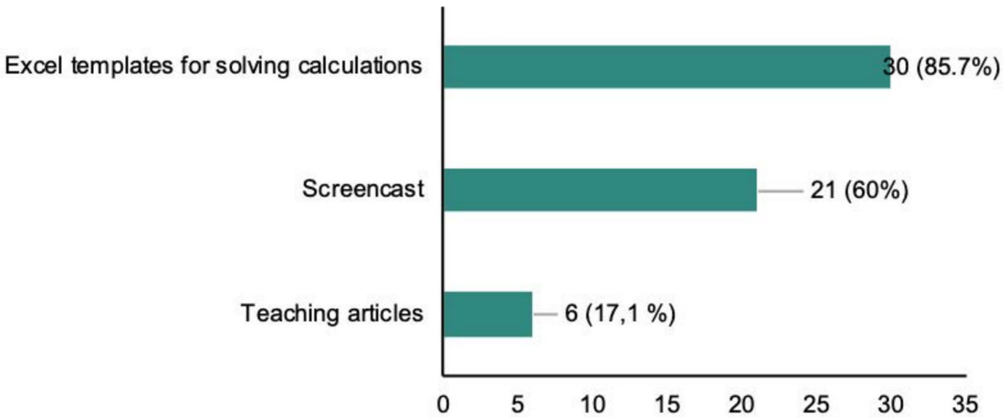

Figure 5. Students' answer to the question: What tools have been most useful to you for learning the theoretical-practical contents?

In the case of the query: In the context of learning practical content at Bioprocess Engineering I, select the option that best suits your opinion regarding the advantages of using the PoliformaT Lessons tool (Fig. 6), most of the students have positively valued the organization that the Lessons tool offers for their learning. However, 20% of them believe that it does not offer any additional advantage in comparison to the folders with information of Resources in PoliformaT.

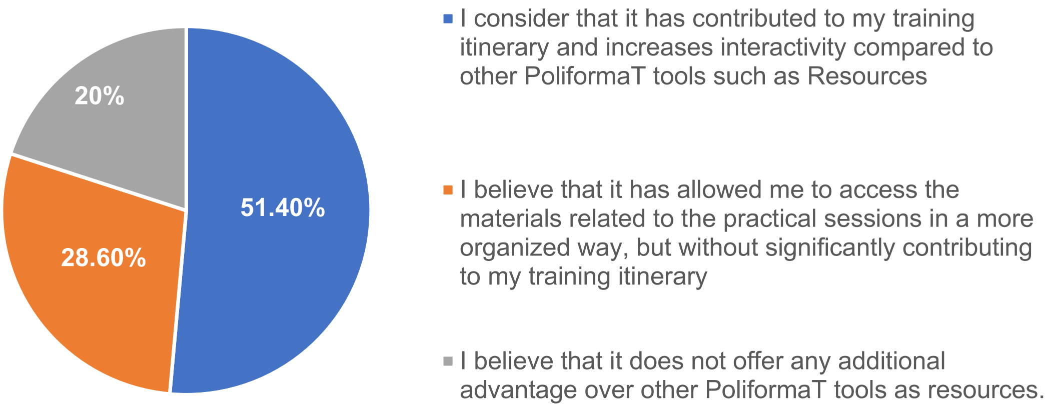

Figure 6. Students' answer to the query: In the context of learning practical content at Bioprocess Engineering I, select the option that best suits your opinion regarding the advantages of using the PoliformaT Lessons tool

Finally, in the query: **The Teams platform has allowed you to follow the practical tasks in a way equivalent to face-to-face teaching**, more than 70% of students agree with this affirmation, whereas around 25% do not think so (Fig. 7).

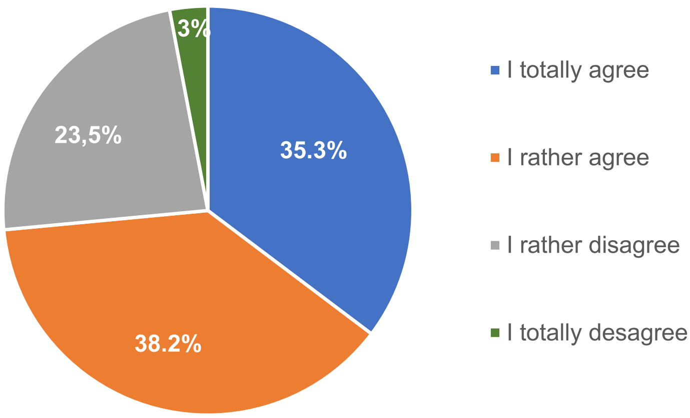

Figure 7. Students' answer to the query: The Teams platform has allowed you to follow the practical tasks in a way equivalent to face-to-face teaching

4 CONCLUSIONS

Despite of the rushed actions taken due to the current COVID-19 pandemics' needs, a successful adaptation of the contents to impart the practical tasks in Bioprocess Engineering I was achieved. The use of Teams® was a key aspect that allowed for implementing a combined online-onsite development of the practical lessons, as acknowledged by 70% of the students. Thus, this teaching modality was able to replace the completely onsite traditional teaching with no drawbacks. Specifically developed materials to support the learning process were also appreciated, being the calculations sheet templates considered as the most valuable resource. The teachers of the subject conclude their instruction of this subject with the perception of a successful outcome, despite the initial hindrances related to the pandemics. In conclusion, this developed model for teaching Bioprocess Engineering practical tasks could be implemented in other universities or in other subjects with similar characteristics.

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