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Remote Learning of Biochemestry During the COVID-19 Pandemic: The Case of Undergraduate Students in Bogota, Colombia

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ABSTRACT

The COVID-19 pandemic forced the implementation of global emergency measures based on social distancing; however, teaching remote classes demands virtual pedagogical strategies that are not traditionally used in the Colombian public education system. Currently, there is no data about the possible effects of remote and e-learning in basic sciences in our country. In this work, the perception of students about remote classes of biochemistry during the COVID-19 pandemic was assessed. A virtual survey was applied to undergraduate students during two consecutive academic periods (2020-I and 2020-II), corresponding to the length of time that university students were confined in Colombia. The courses were taught synchronously online, and the recordings of classes were shared with the students throughout the semesters. The students were previously informed about the main objective of the survey, which was voluntarily and anonymously answered after taking the final exam. The results showed that students have an overall acceptance of remote learning, highlighting that virtual tools facilitated the understanding of the topics, increased assessment performance, and promoted self-learning. In addition, most students stated that they would like to continue biochemistry classes remotely. This pilot study suggests that remote learning is a very useful resource to strengthen the Colombian public education system in the post-pandemic time, which has general problems related to student desertion and failure due to economic problems.

Keywords: biochemistry, COVID-19 pandemic, student perception, remote classes, Colombia

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1 Introduction

The outbreak of SARS-CoV2 (Severe Acute Respiratory Syndrome Coronavirus 2) was declared a global pandemic by the World Health Organization on March 11th, 2020 (D. & M., 2020; He et al., 2020). To date, the pandemic has spread to almost all countries, has caused the death of several million people (World Health Organization, 2021), and has produced serious socio-economic consequences worldwide (Almeida, 2020).

Colombia is among the top ten countries most affected by the pandemic in the world (Amariles, Granados, Ceballos, & Montoya, 2020; Instituto Nacional de Salud, 2021; World Health Organization, 2021). The Colombian government declared a mandatory preventive lockdown to reduce the number of infections and prevent patient overflow in the public health system;

thus, on-site classes were suspended in schools and universities to avoid student crowding (Nicola et al., 2020; Viner et al., 2020).

In Colombia, nearly 12.8 million students from all educational levels have been affected by the mandatory lockdown (United Nations Educational Scientific and Cultural Organization, 2021). Therefore, the implementation of remote classes, as a direct consequence of the obligatory confinement, was a sudden challenge to the Colombian education system.

The "Universidad Nacional de Colombia" (UNC) has 54,284 enrolled students: 47,279 are undergraduates (86.0%) and are 7,845 graduates (14.0%) (Universidad Nacional de Colombia, 2021a). Undergraduate students come from urban and rural territories with vulnerable populations (e.g., indigenous, or Afro-Colombian populations), some of which are victims of the internal armed conflict that ended recently (Universidad Nacional de Colombia, 2021b).

Biochemistry courses at the UNC are offered to students from health and science programs and are instructed by teachers of the Department of Chemistry (Faculty of Sciences). Until 2019, the courses had been traditionally taught through theoretical lectures covering structural, functional, and metabolic concepts. As a consequence of the COVID-19 pandemic, classroom lectures were adapted to synchronous remote classes using virtual tools, such as Zoom, Google Meet, and Classroom, for students with continuous Internet access. Lecture videos in MP4 format and other materials used during the remote classes were made available for students with problems with Internet access to avoid low academic performance during the lockdown.

The perception of university students about the impact of remote classes on various aspects of their learning experience during the COVID-19 pandemic has been evaluated in several universities of Europe, the USA, and Asia. For example, students of Probability and Statistics from the Czech Republic reported the extensive use of videos and other virtual resources as a replacement for face-to-face lessons; however, they also reported that traditional lectures were preferred (Berkova & Nemec, 2020). Last-year medical students in the United Kingdom showed impaired academic preparation (Choi et al., 2020). Similarly, undergraduate and graduate students in Pakistan indicated that remote classes are not suitable for developing countries with limited Internet access and that face-to-face interaction in traditional classes is necessary (Adnan & Anwar, 2020). In Colombia, there are still no reports on the academic impact of remote classes at the university level. Therefore, this work presents an analysis of the undergraduate student perception about the quality and effect of remote biochemistry classes during the COVID-19 pandemic at the UNC, to gain an insight into the actual impact of distance learning as an alternative for public education in the post-pandemic time.

2 Material and methods

2.1 Course description

Two theoretical Biochemistry courses (Principles of Biochemistry-2023214 and Basic Biochemistry-1000042) were offered by the Department of Chemistry, Faculty of Sciences, of the UNC (Bogota). The courses consisted of two classes per week (two-hour classes) for 16 weeks and were taught to students from biology and dentistry programs. The objective of the courses was to study the structure and function of carbohydrates, lipids, peptides, proteins, and nucleic acids, and their metabolic pathways. For the first two weeks, the classes were given through traditional campus-based lectures, but for the remaining 14 weeks (from March 16th to

June 26th, the time of mandatory lockdown in Colombia) the topics were taught by remote synchronous lectures through Zoom and Google Meet using PowerPoint presentations, plus applied exercises on a virtual whiteboard. With the prior consent of the students, all classes were recorded in MP4 format and shared through the Google Drive platform. Non-cumulative grading of the topics was performed using Moodle software by applying different types of questions, including multiple-choice, true/false, matching, and numerical questions.

2.2 Virtual survey description

After the final exam, a virtual survey was sent to all of the students through Google Forms. The students were previously informed that the main objective of the survey was to evaluate their perception of the quality and academic impact of the remote classes during the mandatory lockdown. The survey was anonymously answered by students, who participated willingly. Only one entry was allowed per respondent. Survey data analysis was performed using GraphPad Prism (version 8.0). To observe the trend of the students' perception over time, the survey was applied to students who took biochemistry courses during two consecutive academic periods (2021-I and 2022-II), comprising the length of the confinement time for university students in Colombia.

3 Results

3.1 Remote classes were highly attended and offered different aspects of quality

To explore the perception of students about biochemistry remote learning during the COVID 19 pandemic at the UNC, a virtual survey was applied to undergraduate students at the end of a one-semester course in 2020-I and 2020-II, encompassing a complete academic year. The majority of students attended the remote classes extensively or used the lecture videos during the academic semester (75.2% of respondents), which indicates active participation. Less than half of the students attended the classes moderately (20.4%) or minimally (4.4%) (Figure 1A), suggesting that there was interest in taking the remote lectures. Moreover, 97.3% of students extensively used the lecture videos during the academic semester as educational support to solve problems, participate in workshops, do assignments, and/or revise theoretical concepts in preparation for exams (Figure 1B). However, some of the students also considered that their attention during the classes was reduced over time, suggesting that novel strategies should be used to capture the students' attention throughout the course (Figure 1C, Topic 2).

Students regarded the quality of remote classes as excellent (28.3%), good (43.0%), or satisfactory (17.7%). Less than 10.0% of the students considered that the classes were of regular or low quality (Figure 2A). Students rated different aspects of the remote classes, including clarity of concepts, use of concise and simple language, development of calculations, management of virtual platforms (e.g., Zoom, Google Meet, Classroom, and Moodle), audio quality, and video and PowerPoint presentations. All these aspects of remote learning were rated from 3.8 / 5.0 to 4.4 / 5.0 on average (Figure 2B).

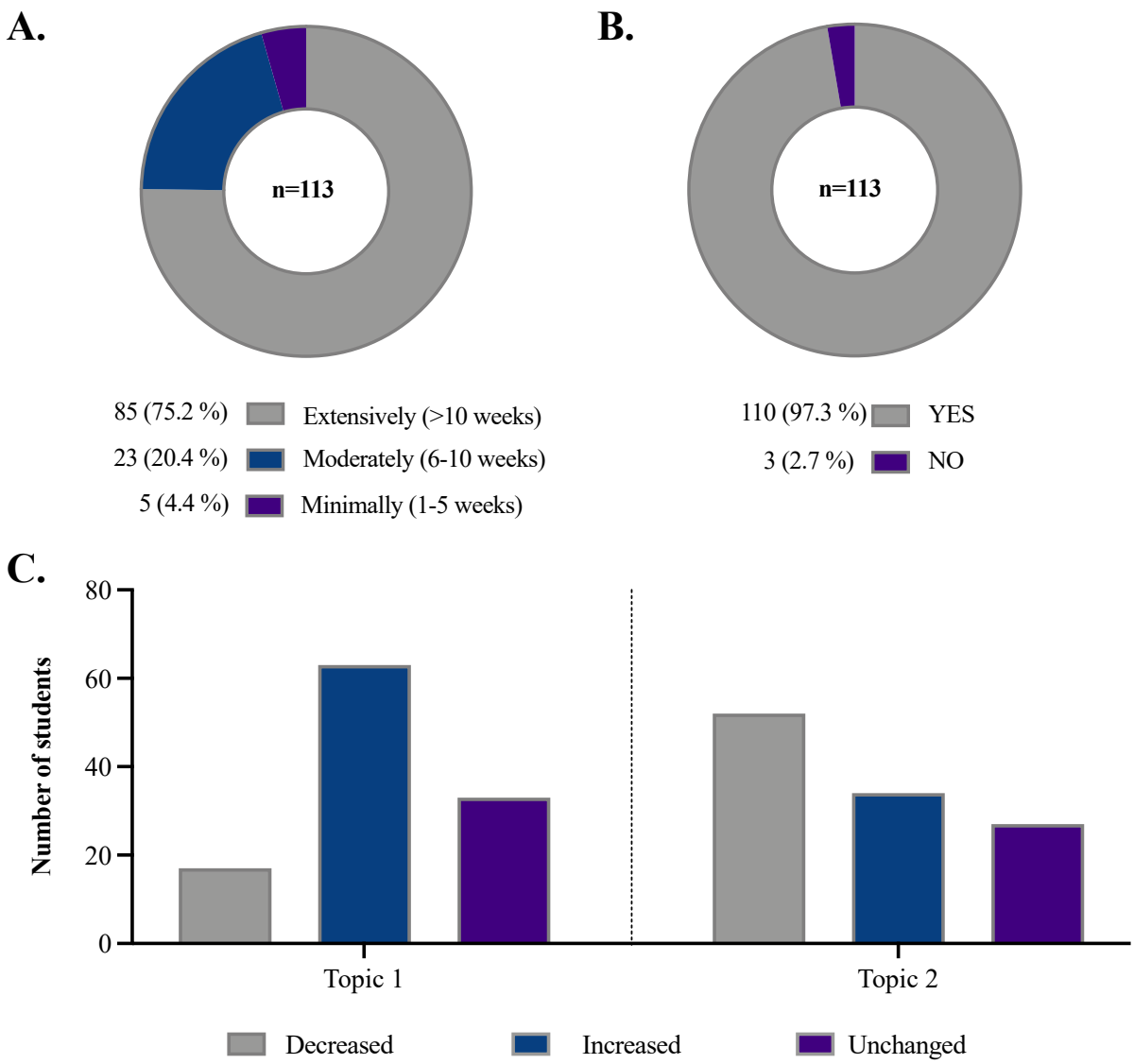

Figure 1. Attendance to remote classes and/or use of videos throughout the academic semester

Note. Student responses are indicated for the following questions: A) To what extent did you attend or use the videos of the remote classes during the semester? B) In addition to attending the remote classes, did you use their videos again at any time during the semester to solve problems, participate in workshops, do assignments, and/or revise concepts? C) Indicate how the remote classes and/or their videos impacted the following aspects of your experience as a student of the theoretical biochemistry course. Topic 1: Your ability to follow the development and completion of the course remotely; Topic 2: Your level of concentration or attention during the course.

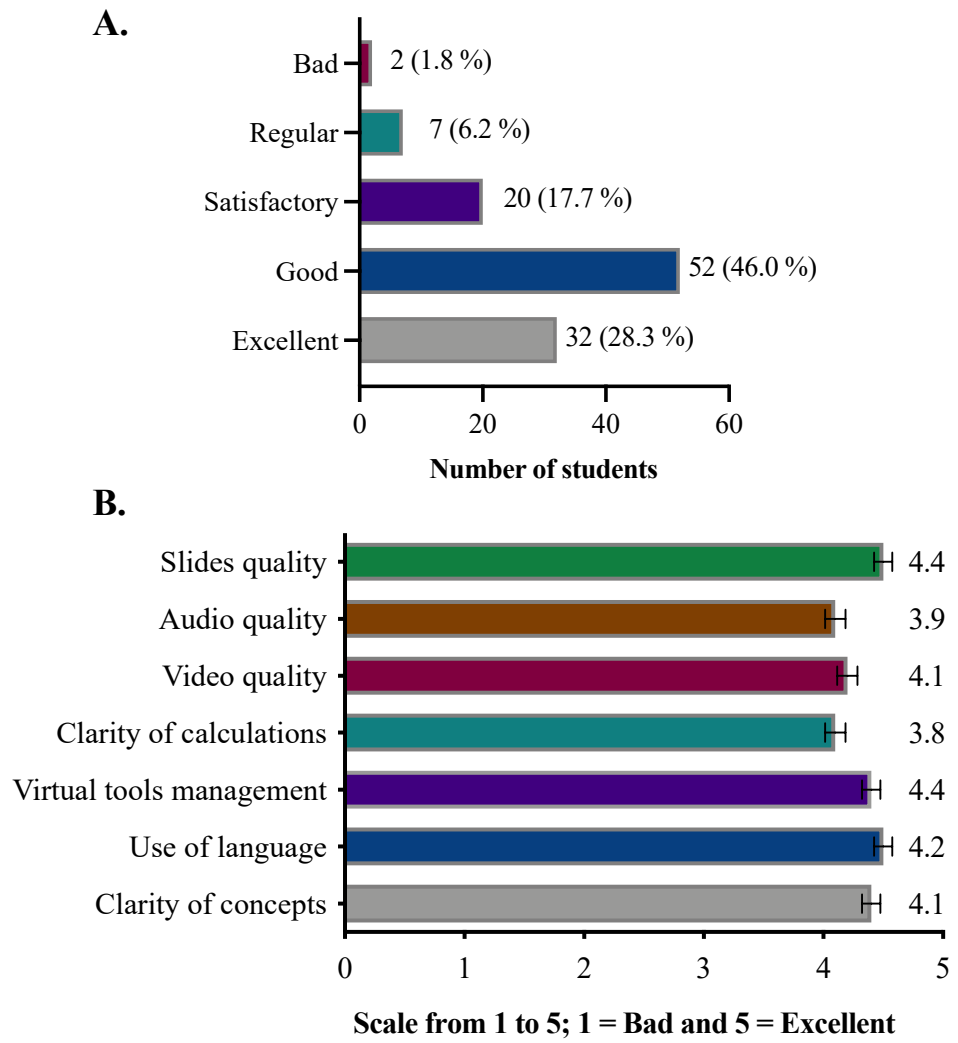

Figure 2. Quality of the remote classes

Note. Student responses are indicated for the following questions: A) How would you rate the quality of the remote classes and/or their videos? B) On a scale of 1 to 5, where 1 = Bad, and 5 = Excellent, how would you rate the following aspects of the remote classes and/or their videos? Data is reported as the average ± SEM of three independent surveys.

3.2 Remote classes and the recorded videos improved student self-learning and the use of other educational resources

We inquired about the possible effect of uploading the recorded videos of the remote lectures, and making them freely available, on the learning process of students. The students expressed those videos of remote classes considerably (46.9%), moderately (46.0%), or limitedly (7.1%) promoted self-learning (Figure 3A), suggesting that this online tool motivated students. On the other hand, there was a simultaneous tendency to use additional educational resources during remote classes. Most students (81.4%) expressed those videos motivated them to check additional books, scientific journals, or websites to complement the topics discussed during the classes (Figure 3B). This behavior suggested a possible connection between remote classes and student self-learning.

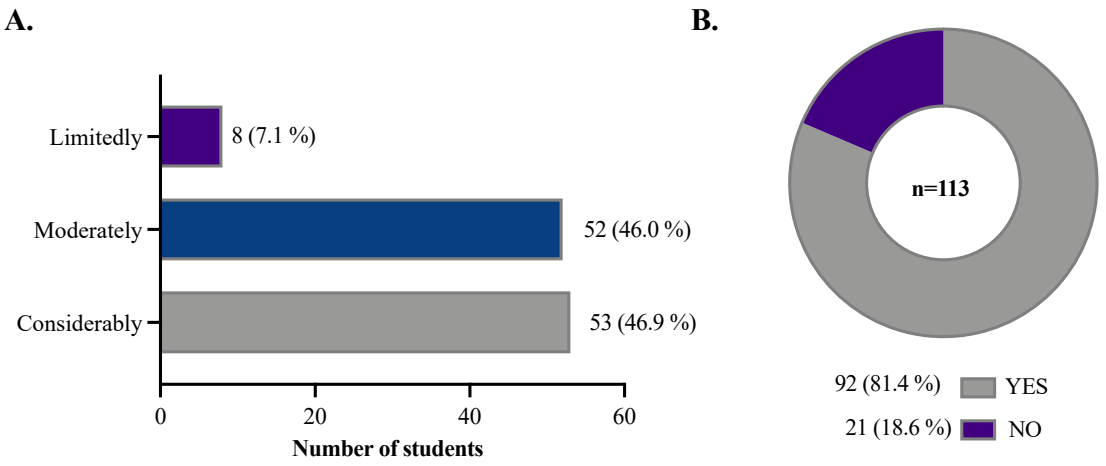

Figure 3. Relationship between remote classes, upload videos online, and other educational resources
Note. Student responses are indicated for the following questions: A) To what extent did the remote classes promote self-learning? B) During the development of the remote classes, did you simultaneously implement any other educational resource such as books or websites to complement the class topics?

3.3 Remote classes facilitated learning basic concepts and improved test-solving abilities

In response to questions about the understanding of concepts and possible changes in the students' ability to answer tests, the students stated that the shift to remote learning increased not only their motivation and interest in biochemistry, but also their understanding of the topics and their ability to solve assignments, quizzes, and tests; thus remote resources were an important resource for obtaining satisfactory grades (Figure 4). Specifically, the grades of students who took remote classes, revised the uploaded videos, etc., increased on average from 3.0/5.0 to 3.3/5.0, relative to the average grades obtained by students in campus-based courses before the pandemic.

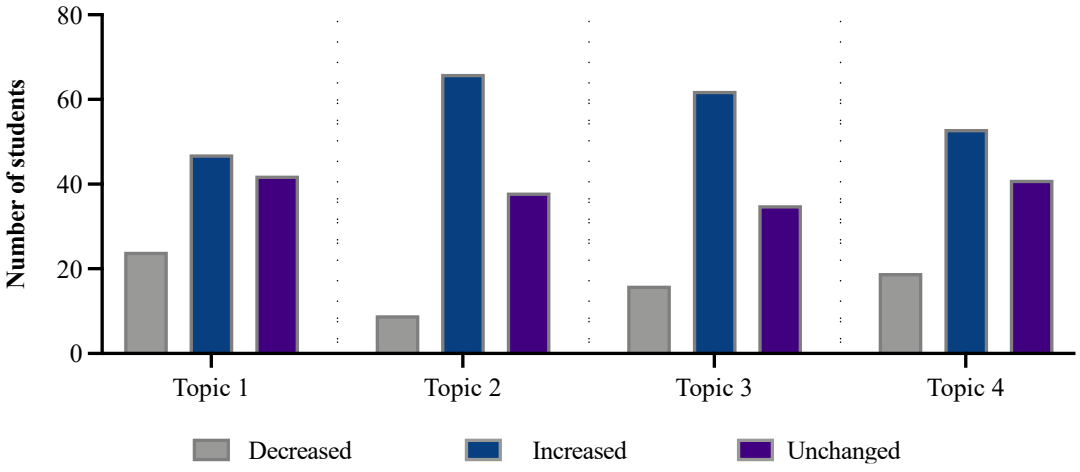

Figure 4. Remote classes impacted different aspects of the learning experience
Note. Student responses are indicated for the following learning topics related to how the remote classes and/or the corresponding videos impacted the next aspects of a student's learning experience in a theoretical biochemistry course: Topic 1: self-reported motivation regarding the course; Topic 2: self-reported interest in biochemistry; Topic 3: self-reported understanding of the topics developed during the semester; Topic 4: self-reported ability to solve problems, participate in workshops, and do assignments, quizzes, and/or partial exams.

Most students considered that the remote classes contributed considerably (60.2%) or moderately (31.8%) to their learning process, while only 8.0% indicated that the remote classes had a low impact on learning biochemistry (Figure 5A). Moreover, repeater students, who previously attended the same course through traditional campus-based lectures, highlighted that remote classes contributed considerably (46.8%) or moderately to their learning experience (40.4%) (Figure 5B). These findings suggested that remote classes and video-recorded lessons facilitated the learning process for more than 85.0% of the students.

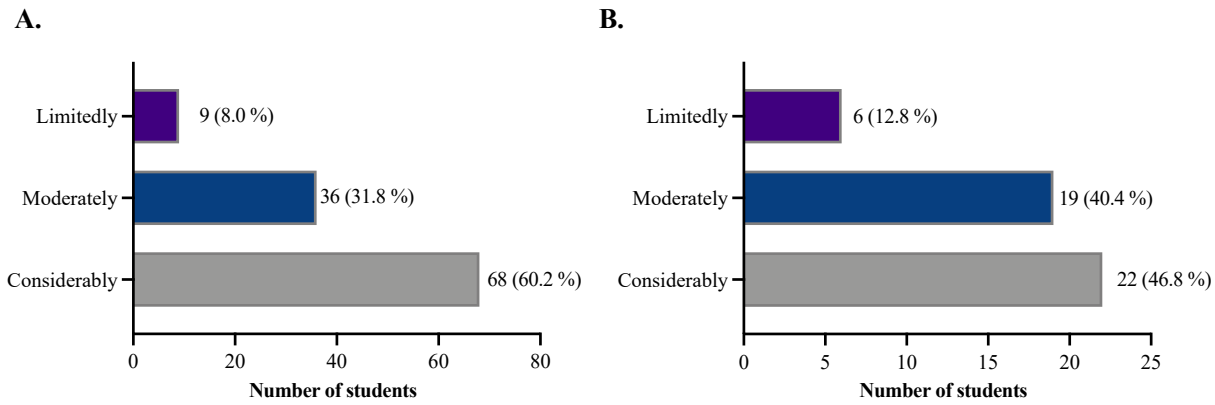

Figure 5. The remote classes contributed to the learning process of the course topics

Note. Student responses are indicated for the following questions: A) To what extent do you consider that the remote classes of the theoretical course in biochemistry contributed to learning the topics? (n = 113). B) If you are a repeater student of the biochemistry course, and compared to the non-virtual modality that you previously attended, to what extent do you consider that you benefited from remote classes and/or the corresponding videos? (n = 47).

3.4 Remote classes are an alternative to increase attendance to classes

Regarding virtual learning as an alternative in a post-pandemic setting, 70.9% of the students considered that remote classes are a suitable alternative to traditional learning (Figure 6A). Most of the students (85.8%) manifested the importance of continued implementation of remote classes either during the COVID-19 pandemic or during any other potential lockdown periods (Figure 6B). Moreover, 75.2% of the students would like to repeat the course through remote classes (Figure 6C). However, as expected, traditional lectures are still the preferred modality (61.9%) for learning biochemistry (Figure 6D).

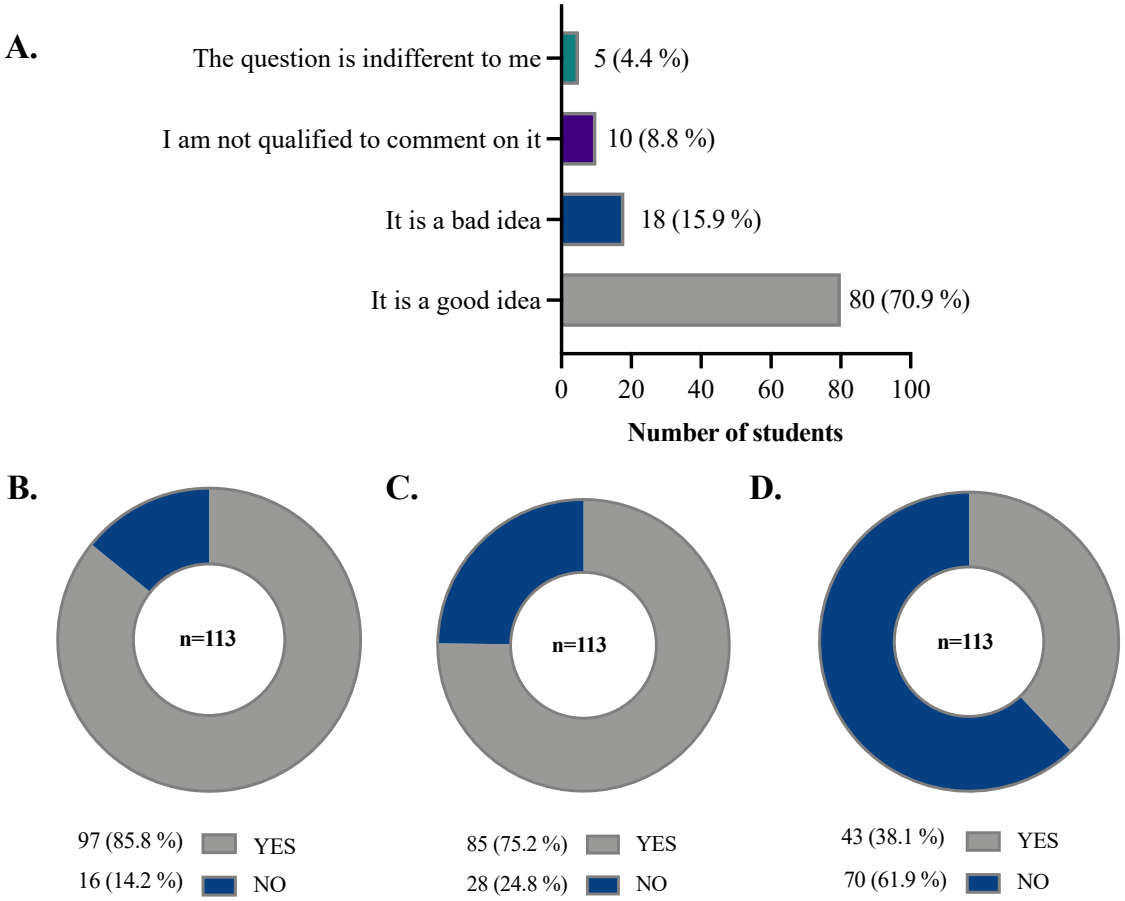

Figure 6. Remote classes are a satisfactory learning tool

Note. Student responses are indicated for the following questions: A) At the end of the biochemistry course, what is your opinion on the implementation of remote classes? Choose the option that best suits your current thinking. B) Should remote classes for theoretical biochemistry continue during the COVID-19 pandemic or any other potential time of confinement? C) Would you repeat the theoretical biochemistry course in a remote learning modality? D) Would you prefer to take the biochemistry course remotely instead of through non-virtual classes?

3.5 Positive and negative aspects of remote learning: open student opinions

Positive and negative aspects of the remote classes were explored through free student opinions. Among the positive aspects of the learning experience, the students mentioned the following themes: “Flexibility to access to the topics”, “Facilitation of the learning experience”, “Allowed repetition of classes to review the topics”, “The class recordings allow you to not get lost”, “It is easier to review the uploaded classes”, “Time is well-used because it is not necessary to go to the campus”, “Recorded lectures require less effort for taking notes”, “The remote classes promote self-discipline”, “The remote classes were didactic”, “Remote classes always provide a front-row seat to attend classes”, among others.

Regarding negative aspects of the remote learning experiences, the students mentioned the following themes: “Poor Internet connection”, “Sometimes, it is hard to be fully concentrated”, “Little interaction with peers”, “External stimuli affects concentration on the class”, “Sometimes, audio failed”, “Difficulty to understand math calculations”, “Remote classes are

exhausting overtime", "Sometimes, remote classes produce more distractions than face-to-face classes", among others.

4 Discussion

The mandatory lockdown due to the COVID-19 pandemic forced Colombian universities to suddenly shift to virtual learning without having broad experience in this teaching modality (Estévez Ceballos, Castro Martínez, & Rodriguez Granobles, 2015). The results of the present study show that students had an overall acceptance of remote learning and that virtual tools facilitated the understanding of biochemistry topics, increased students' performance, and promoted self-learning. Our study suggests that remote learning during the COVID-19 pandemic was a very useful resource for most students. This finding is in keeping with the suggestions of UNESCO on the importance of implementing pedagogical strategies focused on maintaining the teacher-student relationship during the COVID-19 pandemic (United Nations Educational Scientific and Cultural Organization, 2020).

In this study, the students emphasized that remote classes, especially the uploaded videos of the recorded classes, facilitated the understanding of the topics while promoting self-motivation and self-learning in preparation for assignments, quizzes, and exams, which ultimately resulted in better grades. This notion is consistent with previous studies dealing with remote classes for students of other disciplines. For instance, a study conducted with students of Probability and Statistics also reported students' acceptance of the remote classes and virtual material during the COVID-19 pandemic (Berkova & Nemec, 2020). Nonetheless, another study carried out with last-year medical students indicated that the remote classes affected students' confidence and preparedness in the transition from being a student to being a practitioner (Choi et al., 2020). From this perspective, it is possible that the positive or negative impact of remote classes depends on the academic field, and is perhaps more adequate for theoretical disciplines.

Our findings also suggest that remote learning could strengthen Colombian public education (which generally has problems related to student desertion and failure due to economic problems) in the post-pandemic time, as most students reported that they would like to continue biochemistry remote classes because they constituted a useful learning resource. It should be noted that the UNC admits students from different ethnic and minority groups (e.g., mestizos, Afro-Colombian, and indigenous people, among others), and also from territories that include regions that were involved in the Colombian armed conflict that ended recently (Universidad Nacional de Colombia, 2021b); such students usually have adverse economic conditions that potentially affect their academic performance and their ability to attend classes on-campus. Thus, the possibility of attending asynchronous pre-recorded classes, such as those described in this study, will positively impact the academic performance of this group of students and contribute to reducing desertion, a situation that has been markedly increasing in Colombia for years (Rueda Ramírez, Urrego Velásquez, Páez Zapata, Velásquez, & Hernández Ramírez, 2020).

We have identified a general acceptance of both live remote lectures and the corresponding recorded videos. On one hand, the combination of live remote lectures and recorded classes may be quite useful; the mutual construction of basic concepts between teachers and students

through live remote classes (i.e., an elaboration that implies an effective transmission of information) is benefited by a clear communication through the virtual environment. On the other hand, difficulties due to different educational backgrounds or logistic problems could be partially overcome by reviewing the recorded classes. Recording and sharing the videos of the remote classes facilitate permanent contact with concepts and encourages students to review the topics at any time; therefore, favoring the learning process, as was previously described for other virtual education resources (Prakash, Muthuraman, & Anand, 2017; Varghese, Faith, & Jacob, 2012).

Nowadays, college students rely significantly on visual abilities for their learning process (Bobek & Tversky, 2016; Milner, 2014). Although it seemed a minor issue, our results revealed the need to improve the video and audio quality of remote lectures. It has been reported that remote classes should include visual, phonetic, and language clarity, which is markedly influenced by selecting versatile video platforms and proper Internet connectivity. Thus attention should be given to these issues.

The COVID-19 pandemic has changed traditional pedagogical strategies. The analysis of the students' perceptions described in this work suggests that the remote learning process of theoretical courses, such as biochemistry is a good alternative to strengthen Colombian public education in the post-pandemic future, and may contribute to reducing student failure and desertion.

5 Conclusion

This study shows that remote classes during the COVID-19 pandemic had a positive impact on various aspects of the learning process of biochemistry in undergraduate students in Colombia. The survey analysis suggests that high-quality remote classes enhance self-learning and facilitate the understanding of concepts. Additionally, the pedagogical strategy of recording remote classes represents a permanent communication pathway throughout the academic semester, which likely contributes to reducing student failure and desertion. Therefore, combining remote learning approaches with the traditional campus-based lectures could enhance public education strategies in Colombia and other developing countries in the post-COVID-19 future.

6 Supplementary information

Survey: student perception about remote classes of theoretical undergraduate biochemistry courses at Universidad Nacional de Colombia

7 Acknowledgments

We thank our 2020-I and II undergraduate students for attending the remote classes, participating in the virtual survey conducted in this study, and contributing observations and comments to our teaching experience.

8 Availability of data and materials

The datasets and protocols of the manuscript were deposited at Figshare: https://doi.org/10.6084/m9.figshare.12915923.v2

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