

## A FLIPPED CLASSROOM EXPERIENCE IN THE CONTEXT OF A PANDEMIC: COOPERATIVE LEARNING AS A STRATEGY FOR MEANINGFUL STUDENT LEARNING

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### Abstract

Through an initial documentary analysis of the flipped classroom in the context of a pandemic and of the new pedagogical models based on active methodologies or pedagogies and cooperative learning, the experience presented below is part of an innovation project based on the design of cooperative activities focused on students to enhance their meaningful learning and with the aim of improving their satisfaction and motivation and thus, as a consequence, their academic performance.

For the evaluation of this experience, in which 29 students from the theoretical-experimental subject of General Chemistry participated from the Technological Bases Engineering training plan of the Universidad Católica del Norte, three data collection instruments were administered based on the use of the questionnaire and the interview with the students during and at the end of the experience. The main results show high acceptance and satisfaction with the design of the innovation; an improvement in the development of teamwork competence; and a significant impact of the active methodologies and cooperative learning strategies implemented in increasing the academic performance of students.

**Keywords** – Online education, Flipped classroom, Meaningful learning, Self-regulation of learning, Cooperative learning.

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## 1. Introduction

In 2020, the health emergency situation led educational institutions to close for a prolonged period of time, interrupting their usual activity and forcing teachers and students to come up with a new way of continuing education away from physical classrooms. In this new context, distance or non-face-to-face education was the lifeline to overcome the social distance caused by the pandemic (Sangrà, 2020), which brought to the table the need already raised in recent years to rethink distance education as a future strategy for higher education institutions (Fernández, 2017; Bates, 2019).

As Tiana (2015) pointed out, online learning is a change in education based upon two main pillars: the democratization of knowledge through greater accessibility to it, and the modification of traditional teaching methodologies in the field of higher education. Therefore, this change affects from the way content is produced, the way learning is approached, through new models and structures to support this learning, new ways of accessing knowledge and new ways to assess it and accredit it (Gros & Noguera, 2013; Kop, 2011).

One thing is clear: new digital technologies should help teachers improve their teaching, empower students to improve their learning and facilitate intercultural interaction between both groups (Steffens, 2015). In this new context of modifications that involve moving from a learning environment based on books and lectures, to a hybrid or distance environment based on “abundance”, it is necessary to examine different pedagogical models to face this set of changes (Weller, 2011). These new pedagogical models show a gradual shift from teacher-oriented learning to student-oriented learning (Bartolomé & Steffens, 2015), involving them in their own learning process.

One of these changes in approaching learning has been reflected in what is known as the flipped classroom (Fulton, 2012; Milman, 2012; Herreid & Schiller, 2013; Ozdamli & Asiksoy, 2016; Aljaraideh, 2019; Awidi & Paynter, 2019; Torio, 2019). This is a new pedagogical model with which university teachers have begun to experiment for the past few years. Through this model, teachers provide students with master classes recorded on video as homework, and class time is used to conduct more interactive exercises or discussions (Gilboy, Heinerichs & Pazzaglia, 2015). Thus, these new strategies derived from the flipped classroom transfer the teaching process outside the classroom and use face-to-face time with the teacher to facilitate and enhance other learning and skills development. This promotes greater social interaction and problem solving with the class group, enhancing the autonomy and reflection of the student and enabling them to lead their own learning (Tourón & Santiago, 2015; Santiago & Bergmann, 2018).

If we want students to truly be at the core of their learning process, we must first ensure that they have truly meaningful learning (Townsend, Mooren, Tuck & Wilton, 1998; Biggs & Tang, 2011; Carranza & Caldera, 2018; Salazar, 2018; Matienzo, 2020). Meaningful learning is consistent with the competency-based approach and is enhanced through the use of active pedagogies (or methodologies) that focus this learning on students and, above all, on the development of their competencies (Rivera-Muñoz, 2004). This is why we work based on tasks where the student actively participates in experiences in which they have to explore and systematize information, discuss concepts, comment and expose points of view, seek solutions and, ultimately, solve problems analogous to real ones and in interaction with others. Specific examples of active methodologies are problem-based learning, project-based learning, or gamification. It is through this type of activities –which must be based on the interests, knowledge and previous experiences of our students– that the student must be able to integrate their previous knowledge with that of new acquisition, so that this new knowledge or learning is meaningful to them and can help develop new skills.

One of these new skills is the ability of students to learn how to learn or to self-regulate. Learning to learn could be considered the ability to initiate learning and persist in it. That is why this competence has cognitive, metacognitive and affective components. Due to this self-teaching nature, metacognition is closely linked to virtual learning environments (Zapata, 2015).

Specifically, Pintrich (2000) states that self-regulated learning is an active and constructive process from which students establish new objectives for their own learning process and monitor their progress. In this way, the generation of self-regulation processes in higher education students has become a key strategy to contribute to the development of abilities, skills, and even attitudes that will ensure permanent and lifelong learning. A common goal shared by many of the educational models focused on competence development (De la Cruz & Abreu, 2017).

The perception of this new learning through the use of active pedagogies is closely related to the satisfaction of students with respect to the methodology that has enabled it to be more significant

(Romero, Buzón & Touron, 2019). This satisfaction is what will make these students enjoy what they do in class more, take more interest, be more self-assured and confident and pay more attention. And specifically, from the pedagogical point of view, active methodologies stimulate the interest and motivation of students towards learning, giving them more autonomy and even favouring a more formative assessment process of learning (Rivera-Muñoz, 2004).

In this sense, the type of learning experiences promoted by active pedagogies is complemented by an authentic assessment that accounts for the development of knowledge and skills based on tangible evidence and perceived as significant by students. In this sense, the assessment is conceived as a constituent element of the activity, formative and intimately intertwined. This assessment can be designed by the teaching staff or faculty, or in collaboration with the students, and implies applying criteria related to a process of knowledge construction and competence development whose parameters are given by the real situations that inspire it (Rivera-Muñoz, 2004).

In fact, cooperative learning, which is one of the most widely used active methodologies (Cuseo, 1996; Felder & Brent, 2007), encourages the creation of small groups in which students work together to maximize everyone's learning (Lara, 2001). Specifically, the didactic strategies to carry out cooperative learning are quite varied, but all of them must integrate five basic elements (Johnson, Johnson & Smith, 1994): 1) positive interdependence, 2) individual and group responsibility, 3) interaction stimulation, 4) personal and group attitudes and skills, and 5) group assessment.

In this context, cooperative learning is presented as one of the active methodologies that get students to participate in their learning process. At a general level, some research such as that of Cuseo (1996) has shown that cooperative learning increases student satisfaction with the learning experience and promotes more positive attitudes towards the subject matter. Along the same lines, Ovejero (2018), after a review of different experimental works with cooperative programs, highlighted its importance in improving the intrinsic motivation of students, in self-esteem, as well as in the development of their skills and abilities. For Orlick (1990), cooperative teaching programs contribute to an increase in social behaviour in students. Similarly, Slavin (1991) indicates that various experimental studies where cooperative learning methods have been applied have led to an improvement in relationships between students, as well as greater self-esteem and a more positive attitude towards what they are learning. Thus, participatory practices promote greater motivation both among students with respect to their own learning process, and among teachers in the training process.

In this sense, the cooperative learning experience presented below is based on a holistic conception of the teaching and learning process where social exchange becomes one of the key axes of the organization of the classroom (Serrano, 1996). **Specifically, this article is based on an experience that seeks to promote cooperative learning through group work, all under the flipped classroom model, which enhances student autonomy and reflection**

## 2. Design/Methodology/Approach

The experience presented below is part of an innovation project conducted in the laboratory portion of the theoretical-experimental subject of General Chemistry, which is part of the Technological Bases Engineering training plan of the Universidad Católica del Norte (eight-semester engineering programme). Specifically, this is a subject that is taught in the first and second semesters of each year. Through this laboratory practice, students must achieve the learning outcomes established by demonstrating that they are capable of experimentally illustrating the thematic units studied in the theoretical class.

Specifically, the subject of General Chemistry has 5 SCT (Transferable Credit System) distributed in:

- 4.5 hours of theoretical class;
- 1.5 hours of laboratory;
- and 1.0 hours of weekly self-work.

The innovation was implemented during the second semester of 2020 in the context of a pandemic, which entailed a great challenge in conducting the laboratory experiences that were carried out face to face at the university and adapting its development remotely due to confinements or quarantines decreed by the health authority.

In addition to the challenge of having to teach remotely due to the emergency situation, the subject of General Chemistry was already considered a critical subject due to its low pass rate and grade point averages, and, therefore, its very low academic performance. Specifically, as presented in the following table (Table 1), between the comparative period of the 2016, 2017 and 2018 academic years, the average pass rate of the subject, of the theoretical class component, and of the laboratory practices did not reach 50%, while the average grade did not exceed 4.0 out of 7.0. This starting situation could be due to both the type of learning activities and the lack of interaction and cooperation between the students of the subject.

	<b>Of the subject</b>	<b>Of the theoretical class</b>	<b>Of laboratory practices</b>
Average pass rate	31%	29%	54%
Average grade	3.3/7	3.2/7	4.0/7

Table 1. Key average data on the starting situation of the theoretical-experimental subject General Chemistry during the academic years 2016, 2017 and 2018

This is why the innovation presented below was conducted with the aim of improving the low pass rate and academic performance in the General Chemistry subject. For this, in order to overcome the situation described above, cooperative activities focused on students were designed to enhance their meaningful learning and increase their motivation and, as a consequence, improve the pass rate and final grade.

During the semester in which the innovation was implemented, 38 students were enrolled in the course, with 34 students completing the semester. The difference was due to students who decided either to cancel the registration for the semester, freeze the degree, or eliminate the subject. In addition, of the 34 students who finished their semester, 5 had validated the laboratory component and so did not participate in the innovation. Therefore, the article presented below is based on a sample of 29 students.

For the teaching innovation carried out, six laboratory sessions were held online, based on the flipped classroom model. Specifically, the laboratory work to be developed had a practical component and a research component where they had to investigate hypothetical situations that were presented to them.

Depending on the activity to be developed, students had to complete a series of exercises that required calculations from unstructured problems, as fixed data was not expected as a result. Instead, it was proposed that the students choose the values within a margin indicated in the instructions. With this strategy, greater involvement was sought from students in their own learning process, placing them at the centre of it, as they had to present coherent solutions from the chemistry point of view. To validate the results, they had to write their associated reasoning step by step, thus encouraging metacognition and the use of metacognitive strategies for learning.

Each practical activity (a total of 6) was based on ensuring that the student achieved the learning outcome. In this way, the students had to demonstrate experimentally the thematic units studied in the theoretical classes. For each practical activity to be developed, the teacher presented one or several development alternatives, as they were tasks to be conducted in their homes due to the previously described pandemic context. As an example, below (Figures 1 and 2), the statement and these solutions or alternatives of the first activity or laboratory work are shown.

In addition, with the aim of turning this laboratory work into a truly significant or meaningful activity for student learning, small open-ended question forms were designed and distributed after each practical

activity, to encourage self-reflection and self-regulation of their learning. Subsequently, they had to complete a qualified test.

Using what they have learned in the online laboratory, students will need to calculate and compare the density of some elements that they have at home. We recommend using an egg, a small potato or tomato, a couple of screws or nails, or something else available at home. This will be called the **“object of study”**. The object of study must be defined as a team so that there are not different objects of study in the same group.

As this is a group activity, each participant must conduct the experience individually, while data analysis, comparing results, information searches and discussion of the work will be cooperative.

They will need to record the mass and volume of the object of study. If they have scales, they can record the mass. If they have a measuring cup or flask, they can measure the volume. Alternatives will be shown if scales and/or graduated cups/flasks are unavailable.

**Once they have recorded the mass and volume, they will be able to calculate the experimental density of the object of study, and they will have to make a comparison with information found on the Internet and report a single value.**

Figure 1. Statement of laboratory work 1 based on the “Study of the density of irregular bodies at home”

**A. Alternative to using scales (materials can be changed freely):**

- With the use of a ruler and a pencil you can simulate scales.
- As a counterweight, use elements that you have at home where they indicate the mass and, with that, they will obtain an approximate mass value.

**B. Alternatives to the use of a graduated flask (materials can be freely changed):**  
As a reference, you can use a standard soda glass and a small cup that have a volume close to 200mL. Alternatively, a standard bowl with a volume close to 350ml can be used. These values are for use as a reference.

From here, what steps should we follow?

**Step 1.**  
Add a glass of water or a bowl of water to a cylindrical container (avoid conical shapes), and mark the height of the volume inside the container with a marker. This volume will be called the initial volume.

**Step 2.**  
Using a ruler, measure the height of the initial volume of water. This height will be called the initial height.

**Step 3.**  
Add the object of study inside the cylindrical container with water and mark the new height of the water. This volume will be called the final volume.

**Step 5.**  
Use the ruler to measure the height of the final volume of water. This height will be called the final height.

Figure 2. Solutions or alternatives of the first laboratory work based on the “Study of the density of irregular bodies at home”

Specifically, three key moments or phases were defined before, during and after the synchronous laboratory practices (Reinoso, Collazos, Martínez & Delgado, 2021), detailed in the Table 2.

For the cooperative work of the third phase of the post-laboratory (see Table 2), the different teams had defined roles for each member (the leader, the questioner and the time manager). These roles were not static and could change as the activity was carried out or as they changed activities. In addition, these teams were formed by affinity, ensuring that each and every member had more or less a common schedule outside of class.

The teams that had the highest degree of achievement in individual activities were given a bonus translated into extra points for team assessments. This bonus was conditional on the work of the teams and the quality of the deliveries made. As an example, if each member of the team had a grade of 4 or

higher, in the individual assessment they were assigned 0.1 points for teamwork. If all members had 5 or higher 0.3 and so on.

Modality	Learning outcomes (LO)	Description	Delivery type
<b>PHASE 1. Pre-laboratory (before)</b>			
Asynchronous modality (individual)	LO1. Understand the core content	Using the institutional platform, the learning sequence is developed, and multiple-choice questions are answered with instant feedback. The resources used can be texts, videos, infographics, etc. The platform forum is used for any questions or concerns that may arise.	Completion of questionnaires on the platform or through Google Forms.
<b>PHASE 2. Laboratory (during)</b>			
Synchronous modality (group)	LO2. Answer questions and concerns from the first phase of the pre-laboratory.  LO3. Understand the key concepts of laboratory work.	In this phase, pending questions and concerns are addressed based on individual and group feedback. In addition, key concepts are developed and exemplified to better guide the work of the students.	No deliverable.
<b>PHASE 3. Post-laboratory (after)</b>			
Asynchronous modality (group)	LO4. Consolidate learning from the delivery of the laboratory activities.	This is the stage of planning and executing the laboratory work. In this phase, the use of the discussion forum is encouraged to ensure feedback prior to the final delivery. After this delivery, group feedback is conducted again with the possibility of improving the previous work.	Delivery report with graphic evidence of the completion of the practical experience to be uploaded to the institutional platform.

Table 2. Description of the three phases of teaching innovation conducted in the theoretical-experimental subject General Chemistry during 2020

To carry out the data collection, different data collection instruments presented below (Table 3) were used in different instances. The choice, adaptation and elaboration of these instruments began first through a review process of the literature presented at the beginning of this article related to the evolution of virtual learning experiences, active methodologies and cooperative learning.

Data-collection instruments	Objectives	Number of responses and participation
Group interview with students	Obtain an intermediate evaluation related to the development of the innovation and thus make methodological adjustments and/or adjust to the detected expectations of the students, if necessary.	24 (82.6% participation)
Questionnaire on cooperative learning	Assess the cooperative learning of teams or groups.	29 (79.3% participation)
Student satisfaction questionnaire	Evaluate the satisfaction and perception of learning related to the teaching innovation developed.	14 (48.3% participation)

Table 3. Data-collecting instruments within the framework of the innovation project carried out in the theoretical-experimental subject General Chemistry during 2020

A first version of the data-collection instrument presented was validated with the collaboration and help of an expert teacher in educational research, as well as the design of the innovation previously.

## 2.1. Group Interview with Students

In addition, an intermediate evaluation was carried out in order to have immediate feedback regarding the development of the innovation and thus be able to make methodological adjustments and/or adjust to the detected expectations of the students, if necessary. To conduct the interview, the following key and basic questions were considered (Table 4):

<b>Group interview with students</b>	
<b>Basic questions to develop</b>	
1.	Have you been able to work as a team? What kind of difficulties have you encountered?
2.	What did you think of the development of the course considering the evaluations and the times set aside for their completion? Does the evaluation form make sense? Have you had any difficulties?
3.	What element or positive aspect do you take away from the online laboratory?
4.	Do you want to add anything else? Something that has not been discussed so far, but you feel is important to talk about?

Table 4. List of closed and open questions of the student satisfaction questionnaire administered within the framework of the innovation project carried out in the theoretical-experimental subject General Chemistry during 2020

The group interview for the intermediate evaluation was conducted during class hours for the students mid-semester and, specifically, it was conducted online through the use of the Zoom platform.

The information collected during the interview was analysed globally, categorising the information in those difficulties for the coordination of the work groups.

Of the 29 students participating in the innovation throughout the semester, from start to finish, 24 participated in the group interview (82.6%).

## 2.2. Questionnaire on Cooperative Learning

To assess cooperative learning within the framework of the innovation project presented, questionnaires based on Angelo and Cross (1993) on team evaluation were used. This instrument was made up of 4 closed questions and 3 open questions (Table 5). At the beginning, students were asked for their name and surnames and number of the team to which they belonged. From there they could proceed to answer the instrument by responding to the closed questions by selecting one of the previously indicated options.

<b>Questionnaire on cooperative learning</b>			
<b>Closed questions (to be answered on a Likert scale from 1 to 5)</b>	<b>Open questions</b>		
1.	How many students actively participated?	1.	Specify what you learned by working on a team.
2.	How many students on the team were prepared for the activity?	2.	Specify what your partner learned from you by working as a team.
3.	How effective was the team's work?	3.	Provide an example of what you would improve in teamwork to promote learning for all your colleagues
4.	Distribute 9 points among the team members according to their contribution to the work done. More work, more points. Less work, fewer points. The total sum of the team must be 9 points.		

Table 5. List of closed and open questions of the student satisfaction questionnaire administered within the framework of the innovation project carried out in the theoretical-experimental subject General Chemistry during 2020

These questionnaires on cooperative learning were administered at the end of the semester using the Google Forms tool and requesting access through the institutional email to identify the students. For the treatment of quantitative data, descriptive statistics procedures were applied, and for qualitative data, work was done on the categorisation of information based on the systematic methodology grounded theory (Hernández-Carrera, 2014).

Of the 29 students participating in the innovation throughout the semester, from start to finish, 23 answered the questionnaire on cooperative learning (79.3%).

### 2.3. Student Satisfaction Questionnaire

To evaluate the innovation, a questionnaire adapted from Marciniak (2017) was used for this project on the implementation of methodological proposals for the design of a virtual course based on questions related to the dynamics of the work carried out, contents, resources, independent work, teamwork, commitment, feedback, self-assessment and reflection, as well as possible elements to highlight and improve.

Specifically, this instrument was made up of 6 closed questions and 2 open questions (Table 6). The closed questions were designed using a Likert scale from 1 (very bad) to 5 (very good).

<b>Student satisfaction questionnaire</b>	
<b>Closed questions (to be answered on a Likert scale from 1 to 5)</b>	<b>Open questions</b>
1. Do you consider that the content of the course was appropriate? 2. How do you evaluate the quality of the teaching material? 3. How do you evaluate the learning activities? 4. How do you evaluate the quality of the online teacher's explanations or statements to conduct the learning activities? 5. How do you rate the response time of the online teacher? 6. How do you evaluate your commitment to the online modality?	1. Based on your experience in the online modality, what can be improved? 2. Would you add new elements that were not present this semester?

Table 6. List of closed and open questions on the student satisfaction questionnaire administered within the framework of the innovation project carried out in the theoretical-experimental subject General Chemistry during 2020

These student satisfaction questionnaires were administered using the Google Forms tool and they requested access through the institutional email to identify the students. For the treatment of quantitative data, descriptive statistics procedures were applied, and for qualitative data, work was done on the categorisation of information based on the systematic methodology grounded theory (Hernández-Carrera, 2014).

Of the 29 students participating in the innovation throughout the semester, from start to finish, 14 answered the satisfaction questionnaire (48.3%).

Apart from the instrumentation already described, the cooperative learning of students was also monitored through the preparation and delivery of the group meeting minutes following the format provided at the beginning of the semester. Based on this data collection instrument, the teams had to highlight and describe the following points:

- The type of meeting (planning, coordination, execution, doubts, etc.);
- the date held;
- the start and end time;
- the location or platform where held;
- the list of topics covered;
- agreements;
- those responsible for each of the agreements;
- and the deadlines for reaching the closed agreements.



All submissions by the students (individual submissions, group work, meeting minutes, etc.) were made through the institutional Moodle-based LMS platform.

Finally, as evidence for the evaluation of the innovation carried out, the grades of the course collected from the institutional platform were considered to compare them with the academic performance of students in previous years.

### 3. Results

With the aim of analysing the methodology implemented within the framework of an innovation experience based on meaningful and cooperative strategies for the improvement of the student’s learning process and, as a consequence, their qualification and academic performance, this article presents and analyses the results of data collection instruments based on:

1. The questionnaire on cooperative learning;
2. the student satisfaction questionnaire;
3. and course grades (passing percentages and grade averages compared with previous courses).

In addition, to complement and help better interpret the information from these data collection instruments, this article also considers the point of view of the student body collected through the group interviews.

#### 3.1. Questionnaire on Cooperative Learning

This questionnaire on cooperative learning was administered to evaluate the cooperative learning of teams or groups and had a participation rate of 79.3%.

The responses to this data collection instrument show that there is a correlation between the question about how many students participated actively (question 1), and how many students on the team were prepared for the activity (question 2). 82.6% show a match between (question 1) and (question 2), and in only 17.4% there are differences showing fewer people prepared for the activity than active participants.

When answering the question about how effective the team’s work was (question 3), 79% answered Very Good (22%) or Good (57%), while 13% of the student body stated that it was Adequate and 9% Inadequate.

The answers to the specific question about the work done by the students in each group (question 4) showed good correlation between the distribution of the workload and the effectiveness of the team.

Specifically, some of the following textual quotes made by the student participating in the questionnaire on cooperative learning stand out (Tables 7, 8 and 9):

<i>“That I lack organization to carry out my work” (student QCW6).</i>
<i>“I learned to listen to the different opinions to reach an agreement” (student QCW10).</i>
<i>“We have been working with this team for a long time, so the motivation and willingness of each one to work is noticeable, and I learned that apart from everything that is learned in a group” (student QCW11).</i>
<i>“Communication and organization” (student QCW14).</i>

Table 7. Open comments from the students through the questionnaire on cooperative learning, question “(1) Specify what you learned by working as a team”

<i>“Perhaps I try to be as responsible as possible regardless of the circumstance” (student QCW9).</i>
<i>“We learned to work together so that no one is left behind in knowledge” (student QCW10).</i>
<i>“The way he wrote or expressed what I do and the effort to learn what I don’t understand, supporting me from them” (QCW12).</i>
<i>“The leadership, if you have a question, ask immediately” (student QCW18).</i>

Table 8. Open comments from the students through the questionnaire on cooperative learning, question “(2) Specify what your partner learned from you when working as a team”

<i>“Know how to keep your word, so as not to harm others, as we are all connected” (student QCW3).</i>
<i>“Be more consistent with what is researched” (student QCW7).</i>
<i>“Being able to meet in person, as there are times when unexpected things happen like a power outage, the internet...” (QCW11).</i>
<i>“Improve communication at specific times, for example, when we make calls, the shyness of the rest is noticeable” (student QCW18).</i>

Table 9. Open comments from the students through the questionnaire on cooperative learning, question “(3) Provide an example of what you would improve in teamwork to promote the learning of all your classmates”

Specifically, among these qualitative comments, the improvement in teamwork skills and the improvement in their motivation stand out.

### 3.2. Student Satisfaction Questionnaire

This questionnaire was administered to evaluate the satisfaction and perception of learning in relation to the teaching innovation developed and had a participation of 48.3%. Firstly, the results of the closed questions of this data collection instrument are presented below (Table 10):

Question	Very good	Good	Neutral	Bad	Very bad
1. Do you feel that the content of the course was appropriate?	36%	36%	21%	7%	0%
2. How do you evaluate the quality of the teaching material?	64%	29%	0%	7%	0%
3. How do you evaluate the learning activities?	50%	36%	14%	0%	0%
4. How do you evaluate the quality of the online teacher’s explanations or statements to conduct the learning activities?	64%	36%	0%	0%	0%
5. How do you rate the response time of the online teacher?	50%	29%	14%	7%	0%
6. How do you evaluate your commitment to the online modality?	50%	43%	0%	7%	0%

Table 10. Answers to the closed questions of the student satisfaction questionnaire

As shown in the previous table (Table 10), the sum of Good and Very Good responses exceeds 70% in all questions, reaching 100% in question 4. This is consistent with the perception collected through the group interview in the intermediate evaluation (82.6% participation) where it was shown that the course agreed with the development of the activities, the material delivered and the proposed learning assessment. That is why there was no need to readjust its methodology, or to rearm the cooperative work teams.

Table 11 and 12 are the results of the open questions of the student satisfaction questionnaire:

Question	Nothing	More feedback	Queries	More virtual examples	Material	Methodology
1. According to your experience in the online modality, what can be improved?	43%	14%	14%	7%	14%	7%

Table 11. Responses to the first open question of the student satisfaction questionnaire

Based on the open responses to the questionnaire, it was possible to categorise that 43% considered that it was not necessary to improve anything, favouring the design and development of the innovation.

Further, 14% of the student body considered that the speed or time of feedback could be improved, the consultation instances expanded, and the graphic quality of the didactic material delivered could be better.

Finally, 7% considered that the innovation conducted could be improved through explanatory capsules; that is, explanatory videos of the experiments or exercises to be solved. And 7% considered that the option of doing the work individually could also be given without the need to be cooperative: “The works would have been better alone; in some there was not much commitment” (student SSQ15).

Question	Nothing	More feedback	Queries	More virtual examples	Material
2. Would you add some new elements that were not present this semester?	71%	7%	7%	7%	7%

Table 12. Responses to the second open question of the student satisfaction questionnaire

When asking about possible new elements to incorporate into the teaching innovation, most of students considered that they were not necessary, while others believed that new instances of feedback would be positive (7%), as well as special consultation sessions (7%), additional videos and capsules (7%), and incorporating more development exercises in laboratory work (7%).

Specifically, some of the following textual quotes made by the students participating in this satisfaction questionnaire stand out (Table 13):

<i>“From my point of view, this semester was very good. I don’t see how to improve it even more”</i> (student SSQ2).
<i>“I think the modality was good, I can’t find any faults with it”</i> (student SSQ8).
<i>“The requirement of extra material. There are topics that are not easy to understand outside the context of the laboratory, which is why they are not positively understood and they complicate drafting the subsequent report”</i> (student SSQ6).
<i>“An exclusive session for consultations”</i> (student SSQ11).
<i>“Give visual examples of what the (visual) result should be when doing the experience”</i> (student SSQ17).

Table 13. Open comments from the students through the student satisfaction questionnaire regarding the overall assessment of the innovation experience

Through this questionnaire, the students expressed that they were satisfied with the activities and the deadlines, valuing very highly the element of continuous feedback for the improvement of their deliveries.

### 3.3. Final Grades

As shown in the table below (Table 14), when comparing the results obtained at the end of the innovation significant increases are seen, reaching 79% passing in the laboratory and 71% passing in the subject (compared to previous years’ averages based on 54% lab pass and 31% course pass):

	Of the subject		Of the theoretical classes		Of laboratory practices	
	Average 2016, 2017 and 2018	2020	Average 2016, 2017 and 2018	2020	Average 2016, 2017 and 2018	2020
Average pass percentage	31%	71%	29%	53%	54%	79%
Grade average	3.3/7	3.9/7	3.2/7	3.6/7	4.0/7	4.5/7

Table 14. Comparative analysis of the results related to the academic performance of the student body in the different academic years

Finally, the averages of the grades obtained in the course were analysed, where the minimum grade is 1, a passing grade for students is 4, and the highest grade is 7. From the innovation conducted based on meaningful and cooperative learning, the results (see Table 14) show a significant increase, reaching 4.5 in the laboratory average and 3.9 in the subject average, while the averages of previous years were 4.0 (laboratory) and 3.3 (subject).

#### 4. Conclusions

The innovation experience presented in this article is part of the theoretical-experimental subject General Chemistry that is part of the Technological Bases Engineering training plan at the Universidad Católica del Norte. It is a critical subject due to its low rate of academic performance. For this reason, during 2020 and in a context of a pandemic that forced the methodology to be adapted to a new flipped classroom model (Fulton, 2012; Milman, 2012; Herreid & Schiller, 2013; Tourón & Santiago, 2015; Ozdamli & Asiksoy, 2016; Santiago & Bergmann, 2018; Aljaraideh, 2019; Awidi & Paynter, 2019; Torío, 2019), cooperative activities focused on students were designed to enhance their meaningful learning, with the aim of mobilizing and improving their motivation and, as a consequence, their pass rate and final grades.

Through an exhaustive analysis of the data collection instruments implemented, the results show three key points:

1. High acceptance of and satisfaction with the design of the learning experience;
2. the development of skills related to teamwork competence;
3. and a positive impact on the grades and the pass percentage of the laboratory and, as a consequence, of the subject in general.

Related to the first point, the student satisfaction questionnaires indicate that most of them were satisfied with the experience, showing a positive attitude with the development of the work and the dynamics involved. In this sense, most students stated that they were satisfied and would not change the innovation, and they liked being able to undertake experiences linked to curricular content at home as a meaningful student-centred learning strategy (Townsend et al., 1998; Rivera-Muñoz, 2004; Biggs & Tang, 2011; Carranza & Caldera, 2018; Salazar, 2018; Matienzo, 2020). In addition, the assessment of feedback as a key element for the continuous improvement of the task (Nicol & Macfarlane-Dick, 2006; Hattie & Timperley, 2007; Boud & Molloy, 2013; Ajjawi & Boud, 2017; Carless & Winstone, 2020) was a recurring element in the analysed results.

Secondly, referring to point number two, through the responses to the survey on teamwork, the students made several reflections ensuring the acquisition of new learning through teamwork. This is in accordance with what Lara (2001) proposed, where in small groups the students work together to maximize everyone's learning. In this line, this reflects what has already been pointed out by Orlick (1990) regarding cooperative teaching programs as an improvement in social behaviour, or Slavin (1991) regarding cooperative learning methods for improving relationships between students. In addition, results are consistent with what was stated by Meroño, Calderón and Arias-Estero (2021) regarding cooperative learning improving knowledge, academic performance and even favouring the development of digital skills.

Thirdly and finally, the results of this evaluation of teaching innovation show a high pass percentage of the laboratory and of the final course compared to the average of recent years, which could be due to the increase in satisfaction and motivation related to the experience already mentioned in the two previous points. Studies such as those by Cuseo (1996) and Ovejero (2018), León de Barco, Felipe-Castaño, Iglesias and Latas (2011) and Meroño et al. (2021), have already shown that cooperative learning increases student satisfaction and confidence within the team and, more importantly, increases and promotes new positive attitudes regarding the teaching and learning process and regarding what they are learning.

This leads us to reflect on the need to conduct new innovation experiences that mix virtuality and face-to-face experiences based on practice, where students can learn in non-traditional environments, and where they can compare the learning developed experientially with that of their peers, contrasting, reflecting and reaching agreements to ensure the acquisition and development of teamwork skills through cooperative learning.

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