ACTA SCIENTIAE

ISSN: 2178-7727
DOI: 10.17648/acta.scientiae.6983

Chemistry Laboratory Anxiety in Eighth-grade Students from Barrancabermeja, Colombia

Luis Fernando Ávila-Ascanio [a]
Elgar Gualdron-Pinto [b]

[a] Escuela Normal Superior Cristo Rey, Barrancabermeja, Santander, Colombia.
[b] Universidad de Pamplona, Pamplona, N. Santander, Colombia.

Received for publication 26 Jan. 2022. Accepted after review 30 Nov. 2022
Designated editor: Renato P. dos Santos

ABSTRACT

Background: Very few studies have covered the emotions and performance of high schoolers in chemistry laboratories worldwide. Science teaching should be supported by the use of laboratory practices that allow students to prove theoretical concepts, and the influence of these practices should be studied in detail, especially in the Latin American context, during and after the pandemic produced by SARS-CoV-2. **Objective**: We intend to analyse the influence of chemistry laboratory sessions on the academic performance of six eighth-grade students. **Design**: There was a mixed approach of quantitative data (students' grades and anxiety test results) and qualitative data (students' behaviour in the chemistry laboratory) to answer the research question. This research can be classified as correlational and field-based. **Setting and Participants**: This study took place in Barrancabermeja, Colombia, in a public school; six students (two males and four females) with good grades in science voluntarily applied to the research. **Data collection and analysis**: Quantitative data were collected from the two anxiety tests applied to the students and the grades they obtained in the chemistry subject during their stay in the laboratory sessions. Descriptive statistics were applied to this data. On the other hand, qualitative data was collected from the field diary and the video recordings of the laboratory sessions, analysing students' behavior of students in terms of their cognitive, behavioural and affective performance in the lab. **Results**: It was found that student's academic performance varies widely depending on multiple factors different from just attendance to the laboratory sessions, reaffirming that academic performance is multi-influenced. Also, students showed a noticeable evolution in their cognitive, behavioural and affective performance in the chemistry laboratory, as well as decreased anxiety levels in this space. **Conclusions**: We found that the chemistry laboratory can positively influence students' behaviour but does not directly influence their academic performance. A chemistry laboratory anxiety instrument was applied for the first time in Latin America and can be used in other contexts, taking into account what is mentioned in this work.

Corresponding author: Luis Fernando Ávila-Ascanio. Email: lavila284@unab.edu.co

Keywords: Research; academic performance; chemistry teaching; chemistry laboratory; anxiety.

Ansiedade no laboratório de química em alunos da oitava série de Barrancabermeja, Colômbia

RESUMO

Contexto: Pouquíssimos estudos abordaram as emoções e o desempenho de alunos do ensino médio no laboratório de química no mundo. O ensino de ciências deve ser apoiado pelo uso de práticas laboratoriais que permitam aos alunos comprovar conceitos teóricos, e a influência dessas práticas deve ser estudada detalhadamente, especialmente no contexto latino-americano, durante e após a pandemia produzida pelo SARS-CoV-2. **Objetivo:** Pretendemos analisar a influência das sessões de laboratório de química no desempenho acadêmico de seis alunos do oitavo ano. **Design:** Houve uma abordagem mista de dados quantitativos (notas do aluno e resultados de testes de ansiedade) e dados qualitativos (comportamento do aluno no laboratório de química) para responder à questão de pesquisa. Essa pesquisa pode ser classificada como correlacional e de campo. **Ambiente e participantes:** Este estudo foi realizado em Barrancabermeja, Colômbia; em uma escola pública e seis alunos (dois homens e quatro mulheres) com boas notas em ciências se candidataram voluntariamente para participar da pesquisa. **Coleta e análise de dados**: Os dados quantitativos foram recolhidos a partir dos dois testes de ansiedade aplicados aos alunos e das notas que obtiveram na disciplina de química durante a sua permanência nas sessões laboratoriais. A estatística descritiva foi aplicada a esses dados. Por outro lado, foram coletados dados qualitativos do diário de campo e das gravações em vídeo das sessões de laboratório, analisando o comportamento dos alunos quanto ao seu desempenho cognitivo, comportamental e afetivo no laboratório. **Resultados:** Constatou-se que o desempenho acadêmico dos alunos varia muito em função de múltiplos fatores diferentes apenas da assiduidade às sessões laboratoriais, reafirmando que o desempenho acadêmico é multi-influenciado. Além disso, os alunos apresentaram uma evolução notável no desempenho cognitivo, comportamental e afetivo no laboratório de química, bem como uma diminuição dos níveis de ansiedade neste espaço. **Conclusões:** Constatamos que o laboratório de química pode influenciar positivamente no comportamento dos alunos, mas não tem influência direta no seu desempenho acadêmico. Um instrumento de ansiedade de laboratório de química foi aplicado pela primeira vez na América Latina e pode ser utilizado em outros contextos, levando em consideração o que é mencionado neste trabalho.

Palavras-chave: Pesquisa; performance acadêmica; ensino de química; laboratório de química; ansiedade.

INTRODUCTION

Worldwide, scientists and teachers recognize the importance of the school chemistry laboratory as a space for academic training. In this place, facts studied theoretically are verified, and conditions are given for learning conceptual, procedural and ethical knowledge in aspects related to scientific methodology. There is a promotion of critical and creative reasoning capacities and the development of attitudes such as open-mindedness, objectivity and distrust in value judgments that lack the necessary evidence (American Chemical Society, 2018).

In Colombia, many chemistry teachers do not take their students to the chemistry or other sciences laboratories as often as desired, due to multiple causes, including risks and hazards in the laboratory, some news of accidents suffered by students in school labs, the precariousness in instruments and infrastructure (OECD, 2018), the difficulty of handling discipline, the lack of time in the school year to cover the curricular syllabus and do the corresponding practices (Tamayo Alzate & López Rua, 2012) and the ignorance or omission of principals in the management of this space. Due to this, the student is deprived of using the laboratory as a complementary space for chemistry learning. This is also a limitation to the full development of scientific, critical and reflective thinking of science and its role in society by students (Kilic et al., 2011) and may affect the integration of affective and cognitive learning with the psychomotor. The school chemistry laboratory is an ideal place for meaningful learning to occur (Galloway et al., 2016). Some students manifest during conversations, class evaluations and their learning, big frustration at not seeing their knowledge in natural sciences applied to something practical and tangible.

The present research work applied to the participant students, a translated version into Spanish of the anxiety scale in the chemistry laboratory, constructed and corrected in situ by Craig Bowen (Bowen, 1999) in the research work *Development and score validation of a chemistry laboratory anxiety instrument (CLAI) for college chemistry students*. This instrument is applied in this study for the first time in Latin America. Still, several investigations at an international level, especially in Turkey and Australia, have applied this tool with interesting results. Such is the case of the research carried out by Rummey et al. (2019) in Australia, Turkish works by Kurbanoglu and Akim (2010), Kilic et al. (2011); Kaya and Cetin (2012); and the work of Ural (2016). In all these studies, a translated version of Craig Bowen's scale is applied in different

contexts and finds different results. This study applies the mentioned scale for the first time in Latin America.

In order to answer the research question "What is the influence of laboratory sessions in the context of a research group on the academic performance and chemistry laboratory anxiety of six eight-grade students in a Colombian public school?" this study analyzed concretely the influence of a research group on the academic performance of the students. To do so, the grades of the students in the research group were compared to the ones of the control group; the attitude of the students towards the laboratory was analyzed through video and a field diary, and finally, Bowen's scale was applied to measure anxiety and improper behaviors or feelings towards the laboratory.

THEORETICAL BACKGROUND

Pintrich and De Groot (1990) established three important categories for the study of school motivation: the goals and intentions the student uses to get involved in carrying out a task, the perceived competence and the affective-emotional reactions that are produced in it. These variables are undoubtedly present in the students of this research. Their motivation in the research group does not depend on a quantitative or qualitative grade in the subject but on their own goals and aspirations; their motivation is also influenced by the degree of self-perception of competence in chemistry and its laboratory and the affective-emotional reactions they have both with the group leader and with the rest of their peers. This study takes these characteristics into account and measures the affective-emotional reactions of the students during their participation in the research group through the laboratory behavior scales.

Anxiety is a feeling of uneasiness and worry; it is an exaggerated response to a situation that is perceived as subjectively threatening. The first researchers to talk about anxiety before the study of science were Mallow and Greenburg (1983). These authors pointed out that although there is an optimal level of emotion for the performance of any human task, it is also true that anxiety, being an overreaction, severely undermines trainees' performance. This anxiety is defined as a vague or diffuse fear that occurs in response to the idea of learning science and is the result (like other negative emotions) of messages created by oneself, which come from experiences, dialogues and images stored in our subconscious mind.

Subsequent research in the works of Beyer (1991), Chiarelott and Czerniak (1987), and Mallow (1987), especially carried out in the United States

of America, have the consensus that student anxiety is usually greater in scientific contexts than in the humanities; that it is higher in women than in men, that it decreases as scientific knowledge increases and that greater anxiety produces lower academic performance. In this study, the student-researchers are mostly female (4 out of 6) and will be exposed to two tests that measure their anxiety levels in the chemistry lab. Anxiety definitely is a contributing factor in the overall poor performance of high school students in sciences (Eddy, 2000); especially taking into account that the average performance in the science of 15-year-old Colombian students is 413 points, compared to an average of 489 points in OECD countries in PISA tests. Boys perform better than girls, with a statistically significant difference of 12 points (OECD, 2018).

Also, in the chemistry laboratory, it has been observed that many students feel fear at the idea of their participation in the development of the practice, which can lead to frustration and loss of interest in the students regarding the subject or their activity in the laboratory. Additionally, Keeves and Morgenstern (1992) point out that there are many causes of student anxiety in the chemistry lab, such as previous bad experiences in science classes; exposure to teachers who behave anxious or uncomfortable in laboratory situations, the lack of models, racial or gender stereotyping and stereotyping of scientists in the mainstream media.

This study takes into account all the previously mentioned peculiarities of anxiety and measures the expression of the anxiety of the students during their work in the chemistry laboratory. To do so, it applies a Spanish translation of Craig Bowen's "Laboratory Anxiety Scale", covering five aspects: work with chemicals, use of equipment and procedures, data collection, work with other students and time management.

Laboratory activities have played a central role in the chemistry curriculum because they help the student understand the natural world, seeing the real application of what is seen theoretically in class. There is extensive literature that illustrates that the laboratory provides a unique model of instruction, learning, and assessment (Hofstein et al., 2013).

In this research work, it is sought that the research group students have an understanding of scientific ideas within the framework of the scientific method and that they are highly motivated towards chemistry so that this allows to see a change in the variables of behavior in the laboratory and academic performance.

There are three factors that play a very important role in promoting and controlling student learning in the chemistry laboratory (Hofstein & Lunetta, 1982):

- **Teaching practice**: The teacher must be able to perceive what is required for the activity in the laboratory to build meaningful knowledge and develop science concepts, hopefully using the scientific method. In this study, the teacher of the research group has a crucial role, not only as a controller, leader, organizer and guide but also as a manager of the knowledge quality.
- **Student behavior**: Students must be able to conceive scientific problems and questions, control and manipulate variables, measure, observe, formulate hypotheses, predict, design new experiments to confirm or reject their hypothesis, infer, collect and analyze data and draw conclusions about scientific phenomena. To successfully achieve the acquisition of these skills, the student must acquire a series of basic characteristics in her personality, which include communication skills, discipline, order, cleanliness, critical thinking and problem-solving. This implies that the selection of students for the research group (sampling) must be non-probabilistic and intentional.
- **Type, level and nature of the practice**: Given the particular context of the practices developed in a research group with eighth-grade students, it is relevant to have a precise definition of the type, level and nature of the activities to be developed.

In this study, academic performance was measured as the quantitative value of the grades obtained in each bimester in chemistry. At the institution, students have a four-term school year, that is, four bimesters and grades are given on a scale of one to five, with 3.6 being the minimum passing grade.

A large number of previous studies have measured academic performance as the quantitative value of the grades obtained in monthly, bimonthly, semester or annual periods (Richardson et al., 2012) and have theorized about the intrinsic and extrinsic variables that affect it, such as motivation, personality, cognitive factors of the student, the particularities of the subject taken, the volume of the syllabus in the subjects, the pedagogical approach of each teacher, among others (Rodríguez Portuguez, 2016).

The literature uses the terms “academic achievement”, “academic success”, and “student success” interchangeably. Kuh et al. (2006) came to

define it as academic achievement, involvement in educational activities with a purpose, satisfaction, acquisition of the desired skills, competencies and knowledge, persistence, achievement of educational results and performance after school.

Complementing this concept, York et al. (2015) theorized that environmental variables, student learning processes, persistence and teaching method converge in the concept of academic performance. In addition, they suggest that the term academic performance is well-defined but needs to be better measured because it is multicausal and multifactorial. The present study showed the student's academic performance as a quantitative variable to be analyzed, always taking into account that it depends on multiple factors and intrinsic and extrinsic motivations that go beyond the involvement of students in the chemistry research group.

METHODOLOGY

The research method used in this study is mixed since it makes meta-inferences from the management of quantitative variables and a qualitative category of analysis. The quantitative variables correspond to the grades that show academic performance in the subject and the result of a pretest and posttest of the anxiety scale. On the other hand, the qualitative analysis includes the meanings extracted from the video records and the diary. In this study, neither approach is privileged, but both are given the same status (Johnson et al., 2007).

The resolution of the research problem involves investigative work that consists of five phases that are described below:

Phase I: Statement of the problem and conceptualization to solve it was made. Taking into account that Bowen's instrument was originally designed for American college students, it is considered by the author that the instrument can be suitable for eighth-grade students as well if the appropriate changes are made, as the context of the research is always the same, the chemistry laboratory.

Bowen's anxiety scale was translated into Spanish by the authors and lately revised and validated by Dr. Maria Acuna (PhD in Education at UNAB university) and Dr. Graciela Chalela (PhD in Biochemistry at UNAB university). They examined the adequacy of the translated scale in terms of correct translation to the Spanish language, chemistry competencies for high

school and Educational appropriacy. Some modifications in terms of appropriate translation were implemented to fulfil the characteristics of Spanish grammar, syntax and lexicon. These modifications also made it easier for the instrument to be more age, gender and context-appropriate for the students. The scale in Spanish is shown in appendix 2, and some relevant changes made in the translation are listed in Table 1.

Table 1

Changes in the Spanish translation of the instrument.

Original expression	Literal translation	Context-adapted translation	Observations
Chemistry Laboratory Anxiety Instrument (CLAI): **A Survey on Chemistry Laboratory Experiences.**	Instrumento para la ansiedad en el laboratorio de química: Una encuesta sobre las experiencias en el laboratorio de química.	Instrumento para la medición del comportamiento en el laboratorio de química	It is not convenient for students to read the word "*ansiedad*" (anxiety) in the form.
Neutral	Neutral	No opina	Students will understand better the expression "*No opina*" (no opinions about it) than "*Neutral*" (neutral)
Anxious	Ansioso-a	intranquilo e inseguro	The adjective "*ansioso*" (anxious) is not commonly used by students in Barrancabermeja and could be misunderstood.

The validated scale was applied first as a pilot test and then in the third and twelfth (final) lab sessions. The pilot test was applied on paper, and the other two were applied using a google form.

Phase II: Projection[1]. A call went out for students interested in belonging to the research group, which resulted in self-selected sampling since the group candidates voluntarily applied and understood that they did not obtain benefits in grades for belonging to the research group. Thirteen students were able to obtain the permission and informed consent of their parents, but only six students were able to attend all lab sessions, consolidating themselves as the definite participants of the study. The control group was defined as all eighth-grade students at the school non-belonging to the research group, 198 at the time.

Phase III: Interaction. The first contextual practices (recognition of laboratory material and chemicals) were developed inside the school chemistry laboratory, composed of four benches, a board, and enough reagents and materials for students to use. The pilot test of Bowen's laboratory anxiety test was applied.

The interaction phase was strongly affected in its schedule by the pandemic unleashed by the SARS-CoV-2 virus, which forced students and teachers into mandatory preventive isolation, and caused the subsequent sessions to be developed through the Microsoft® TEAMS platform as a way to communicate using audio and video and showing results of the virtual laboratory practices. In these sessions, the practices were developed, the instruments were applied, and data was collected. Laboratory sessions are listed in Appendix 1.

In face-to-face laboratory sessions, the teacher gave the instructions for the development of the laboratory practice, and students did what was instructed in a 2 hours period. Results in face-to-face sessions used to be shown at the end of the practice, and a short meeting for conclusions was made at the end of each session. After the isolation period, in ICT-mediated lab sessions, students were given clear objectives or procedures to develop in chemistry laboratory software. Results were shown at the end of every session by every

[1] This study had the free and informed consent of the participating students and the educational institution to which they belong. This study was conducted in Colombia, where ethics committee approval is not required. The authors openly and cleanly exempt Acta Scientiae from any of the consequences that may arise, including full assistance and eventual reimbursement for any resulting damage to any of the research participants, according to Resolution No. 510, of April 7, 2016, of the Brazilian National Health Service Council.

student, showing their screen or the teacher giving a general conclusion of the work carried out.

Students in the research group were all time in contact with the control group as they were part of the same classrooms and grades. Laboratory sessions mentioned here were only taken by the research group students as it was outside the class activity. Students in the control group only took the lab sessions stated by the school curriculum. Quizzes, tests, classes, and pieces of homework were the same for both students in the research group and students in the control group.

Phase IV: Evaluation. Data analysis, conclusions and recommendations for future studies were made.

RESULTS AND ANALYSIS

Results on students' anxiety

After applying the CLAI to the research group students, it could be observed that most of the anxiety scores diminished in all students, having as a group a score of 283 points in the pretest to 220 points in the posttest, which indicates a reduction in the anxiety scale of 63 points. This decrease in anxiety is complemented by the attitudinal evolution and the development of more positive emotions towards the chemistry laboratory. These results are similar to those of some studies presented in the state of the art, in which, after exposing students to several laboratory sessions in an academically relaxed environment, there are decreases in anxiety levels.

These results also allowed to corroborate what was proposed by Hofstein et al. (2013), which is that the chemistry laboratory is a unique model of instruction, learning and evaluation, and presents a decrease in the anxiety of the participants in cognitive, motor and memory terms as pointed out by Mazzone (2007).

Next, a detailed analysis of the scales in the CLAI is made (Table 2), comparing the anxiety score in the pretest and posttest of the six students belonging to the research group:

Table 2

Laboratory anxiety scores in the pre and post-tests.

	Pre-test	Post-test	Difference
Scale 1: working with chemicals	57	45	12
Scale 2: using equipment and procedures	60	39	21
Scale 3: collecting data	48	38	10
Scale 4: working with other students	52	49	3
Scale 5: having adequate time	66	49	17
Group anxiety	283	220	63

Firstly, it can be noticed that working with chemical substances, with a difference of twelve points between tests, was the third item with the greatest drop in the perception of anxiety. This can be attributed to the student's knowledge and application of the safety measures in the chemistry laboratory. They were also involved in situations where they had to see or handle chemicals with different degrees of risk. Clearly, the switch to technology-mediated modality also had a significant impact on this result.

On the second scale, using equipment and procedures, there was a difference of twenty-one points between tests, being the item with the greatest drop in the perception of anxiety. This could be due to the students' exposure to procedures previously unknown to them and their interactions in situations where they had to see or use equipment made of different materials. It was noticed that students were more anxious when handling glass-made material in the first sessions, and eventually, they developed more confidence as they had more interactions with these materials. This allowed the improvement of self-perception and promoted students' self-confidence towards laboratory procedures.

The collecting data scale had a difference of ten points between tests. Students gained confidence and skills for data collection, including steps before and after this process, such as generation, processing, storage, management, analysis and interpretation of data such as volumes, temperatures, densities, etc.

In the case of scale four, working with other students, it was noticed that this factor is closely related to the personality of each student, and the difference between tests was minimal as this was never really an anxiety trigger

because these students used to see each other in other classes and even outside academical duties.

Scale five, having adequate time, had a reduction of seventeen points in the anxiety scale. Students finally understood that good planning of the laboratory practice in a complete pre-report and organized team work improves the management of time. They also learned to trust more that the procedures were originally designed for a stipulated time, which should be approximately the same for all groups.

Finally, it is shown that group anxiety considering all scales, decreased by 63 points due to the previously mentioned reasons.

Results on the academic performance

To analyze the academic performance variable, the quantitative value of the grades obtained (Richardson et al., 2012) was taken into account during the bimonthly school term. This variable is multi-causal (Rodríguez Portuguez, 2016) and for this particular, it was strongly influenced by the change in modality from face-to-face to technology-mediated, motivation regarding the subject and the school process, in general, tended to decrease in some students, some others had problems to access to a good quality internet connection or computer equipment; comfort and family conditions in the new place of study (their home) and the loss of spaces for relationships with colleagues would also influence in the general academic performance.

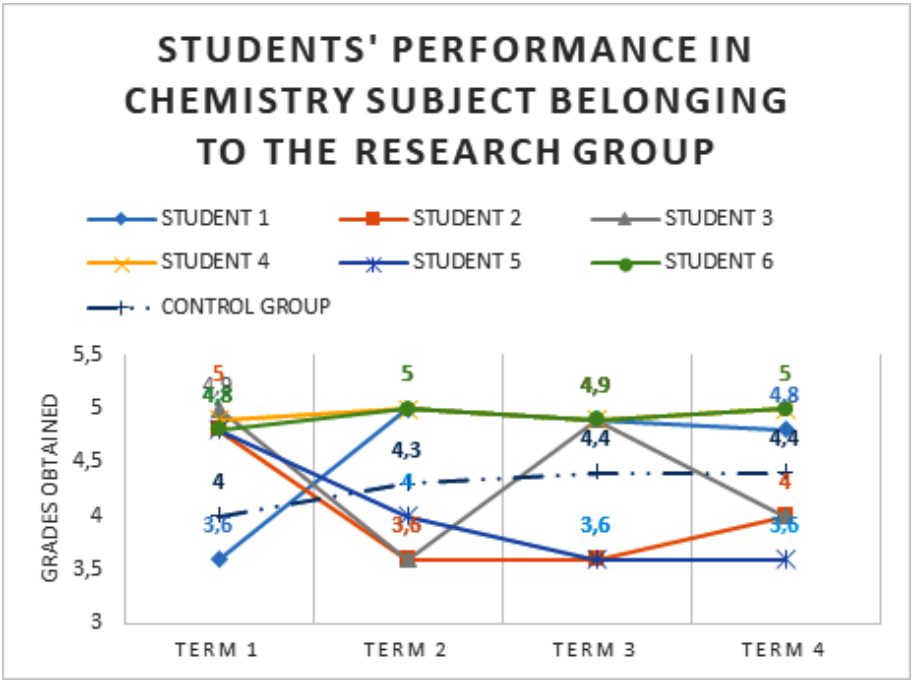
Next, a descriptive and detailed statistical analysis is made of the performance of each of the six students in the chemistry subject. The performance of the six students belonging to the research group was contrasted with that of the control group, 198 students.

It can be inferred from the study of the performance of the students that the variable of academic performance seems not to be directly affected by the permanence of the students in the research group and that their behavior depends entirely on the student, as is evident when the performance of the students is compared with the control group, as can be seen in Figure 1.

In student 1's case, the academic performance variable is positively affected during her stay in the research group, stabilizing in higher-ranking grades after having a minimum passing mark in his first term. This student claims that she likes technology-mediated methodology, although it may mean more work.

Figure 1

Student's performance in chemistry subject belonging to the research group.



On the other hand, student 2 had a negative variation in terms two and three, in which a minimum passing grade is obtained, and recovery is achieved in the fourth term, to basic performance. This student states that she is unmotivated towards the technology-mediated modality, and in the teacher's evaluation committee meeting, other teachers state that the student has lowered her academic performance in all areas.

Student 3 had a very large grade fluctuation, ranging from grades of superior performance in terms one and three to grades of basic performance in terms two and four. This student had a difficult family context that was aggravated by the pandemic. Her economic context is one of limited resources, and she has occasionally expressed internet connection difficulties.

Student 4 maintained a superior performance throughout her stay in the research group. She is recognized in the school for her superior performance in all subjects and excellent behavior.

Student 5 had a negative variation in academic performance during his stay in the research group. He went from superior performance in the first term to basic performance in the second and a minimum passing grade in terms three and four. This student, in particular, reported a lack of motivation towards the school process. His performance in other subjects has also deteriorated.

In the case of Student 6, a higher-level academic performance is maintained throughout the four terms. This student is characterized by his proactivity and commitment to all subjects. The other teachers report the same behavior.

To sum up, it can be inferred from the students' performance that the academic performance variable does not seem to be directly affected by the permanence of the students in the research group. This study, therefore, ratifies what was expressed by the authors referenced in the theoretical framework for academic performance, i.e., that this variable is influenced by multiple internal and external causes of the student and that, in this case, one of the most influential, was how the student used his emotional tools, his resources and his vision of the world, to face the new reality of education mediated by technology; as well as everything that involves studying from home and not attending the physical space of the school.

Based on the above, it can be affirmed that a direct correlation could not be found between the permanence in the research group and the academic performance variable in terms of the quantitative grade of the chemistry subject, as understood in this study.

Results on the attitude towards the chemistry laboratory

Throughout the fifteen practices, it can be observed in the field diary and the recordings a positive evolution in the students' attitude towards the laboratory and chemistry in general. In the same way, students had a significant advance in their research skills since they went from training in basic skills of chemistry laboratory management to proposing and leading school research projects that solve research problems in their closest context. It is thus reaffirmed that the chemistry laboratory, within the context of the research group, provided the students with unique skills development opportunities,

which could not have been given in the regular context of the class, as theorized by Hofstein et al. (2013).

The advances mentioned above were also evidenced by the institution's biology teacher and psychologist, and their concepts, together with what was observed by the researcher, are organized into three dimensions, cognitive, affective and behavioral. The evolution in the indicated dimensions is presented in tables 3, 4 and 5.

Table 3

Students' evolution in the cognitive dimension.

Dimension	Indicators	First session	Last session
Cognitive	Judgments and beliefs	"Difficult" "Dangerous" "Safety rules are boring" "I am better than my partners because I belong to the research group" Basic states of critical thinking and problem-solving skills	"Learn and complement knowledge" "Easy" "Accessible" "Safety rules are necessary" "Proud to belong to the research group" Significant advancement in critical thinking and problem-solving skills

In the cognitive dimension, that is, students' judgments and beliefs concerning the chemistry laboratory, it was established that students went from conceiving the laboratory as a difficult, risky space with boring safety rules; to having a concept of this space as a conducive place to deepen their knowledge of the subject and in which the rules are followed for the welfare of all. Additionally, there is a new sense of belonging to the research group, the subject and its educational institution, as well as an advance in critical thinking and problem-solving skills.

In the behavioral dimension, as shown in table 4, it was found that the student maintained his curiosity, emotion and attitude towards the teacher. However, some students' motivation was diminished, not only towards the research group or the subject but towards their duties as a student. This can be largely explained by the abrupt and forced change in the teaching environment and methodology to which they were accustomed.

Table 4

Evolution of the behavioral dimension.

Dimension	Indicators	First session	Last session
Behavioral	Interaction with the chemistry laboratory, group partners and group leader-teacher.	Competition, incoordination, games, humor, anxiety. Respect and gratitude to the teacher.	Collaborative learning, coordination, serenity, and more academic environment. Respect and gratitude to the teacher.

On the other hand, progress was evidenced in the interaction of the students with their peers, which gradually occurred in the face-to-face sessions and was consolidated in the virtual sessions. It was established that, initially, interactions with peers were disorganized, uncoordinated, competitive and privileged situations of game, humor or vanity (photos, jokes, anxiety).

Subsequently, the interactions on the platform were more organized, mediated by the "Hand raise" tool or with timely interventions without interrupting classmates or teachers within the TEAMS® platform, and the interventions of the students were more academic, deep and focused on the practice topic. This fact can be interpreted from what is established in the investigations of Pintrich and De Groot (1990) since the students acquired greater clarity in the goals and intentions to carry out the tasks, the perceived competence was not significant, but on the contrary, an environment of mutual support was established between colleagues and affective-emotional reactions were neutral, since they occurred behind a screen.

Another aspect studied was the evolution of the affective dimension, as shown in Table 5.

Table 5

Evolution of the affective dimension.

Dimension	Indicators	First session	Last session
Affective	Feelings and emotions	Anxiety Fear Rejection of danger Expectation Teacher does not know the emotional barriers of the students	Gratitude Sense of belonging Security and confidence in own abilities The teacher knows and treats the emotional barriers of the students

More positive emotions could be perceived in the students in the last sessions than in the first ones. Although the change in modality was a determining factor for the demotivation of some students, the participants who remained in the study were more positive, calm and confident towards the laboratory, the group and research in general. This appreciation is consolidated with what was observed by the biology teacher and the school psychologist.

The practice, interaction and trial and error processes experienced in the fifteen sessions consolidated more positive and balanced emotions in the research group students compared to their first sessions. In the last sessions, feelings of unease and concern are not perceived as an exaggerated response to a situation that is perceived as subjectively threatening (Bouras & Holt, 2007), but rather a serenity of the students is perceived in their roles as group leaders or exhibitors. Additionally, the teacher in the last sessions already knows and deals with the emotional barriers of the students.

Therefore, it is found that students who belong to the chemistry research group and attend practice sessions regularly and with motivation present a better attitude towards the laboratory in their final session than in their first session.

In this work, we tried to minimize researcher bias in data collection and analysis of the results as much as possible. Firstly, the participating students applied voluntarily and understood that being part of this study did not mean receiving stimuli in the subject's grade but that their grades depended directly on their work in class and their fulfilment of homework. The notes collected for the analysis were obtained in a consolidated spreadsheet at the end of the school year with the rest of the students in the population.

Secondly, the analysis of the cognitive, affective and behavioral dimensions is done in the triple-blind mode; that is, the researcher, the biology teacher (who evaluates aspects of behavior in the laboratory) and the school psychologist, who evaluates the perceived anxiety and behavior in general of the students.

The format chosen for the field diary proved to be adequate since it enunciated the pertinent criteria to interpret the important events that occurred in each practice. Given the pedagogical approach of the school and the environment generated in the laboratory sessions, it can be evidenced in the videos and notes of the pedagogical diary that the students interact, ask questions and respond spontaneously, without any pressure to being filmed, and with the naturalness and cheerfulness of a teenager in a friendly classroom environment. The results obtained for this category were contrasted through a process of triangulation of researchers and theories.

As mentioned before, the instrument for measuring students' anxiety is a translated version of a globally recognized scale for measuring this variable in the chemistry laboratory environment. The translation of this scale was approved by the education expert María Piedad Acuna and an application pilot was made in the first session of the research group.

The anxiety test was tabulated strictly following the indications given by the author of the original instrument (Bowen, 1999). Its application both times was anonymous; the first time was on paper and the second in digital; in both cases, all the students took the test on the same weekday and at the same time. The results obtained were contrasted with studies of similar methodology, mentioned in the background.

Considering all of the above, the reliability and validity of the data collection and triangulation instruments applied to achieve the objectives can be confirmed.

CONCLUSIONS

As an answer to the research question "What is the influence of laboratory sessions in the context of a research group on the academic performance and chemistry laboratory anxiety of six eight-grade students in a Colombian public school?", it was determined that the permanence in the research group did not have a direct impact on the academic performance of the students in the chemistry subject. This unit of analysis was strongly influenced

by the change in study modality and practices, from face-to-face to virtual, as a result of preventive isolation as a preventive measure against the SARS-CoV-2 virus.

In each student, the modality changes implied particular situations, scenarios and challenges, which they assumed according to their emotional tools and contexts. All of them had different performances in the grades of the subject during their permanence in the research group, which makes it possible to rule out the hypothesis of a direct relationship between the research group and the academic performance expressed by the grades. This finding is significant since it rejects an assumption initially raised in the investigation.

There was an improvement in the students' attitude towards the chemistry laboratory in the three dimensions analyzed in this study. In the first place, in the cognitive dimension, the initial judgments and beliefs students had towards the laboratory improved. Second, improvement in the behavioral dimension indicated more assertive interactions in the laboratory, both with peers and with the teacher. Finally, the affective dimension improved, reflected in more positive feelings and emotions towards the laboratory. Consequently, the research group improved the attitude towards the laboratory of the students, when comparing their first and last sessions.

The decrease in the anxiety of the research group students towards the context of the chemistry laboratory is complemented by the attitudinal evolution and the development of more positive emotions towards this space, consolidating it as a unique place for instruction, learning and evaluation, which allows improvement in cognitive, motor and memory skills.

Based on the application of the instrument, there was a marked decrease in group anxiety, from 283 points in the pretest to 220 points in the posttest, which indicates a reduction in the anxiety scale of 63 points. This scale considered a range of 120 points for minimum group anxiety and 600 points for maximum group anxiety. These results show that there was a decrease in the average scores and scores of all the subscales of the test, which, in turn, shows that the students developed security and self-confidence in the five items of the test: manipulation of chemical substances, the use of equipment, proper laboratory procedures, data collection, peer work, and proper time management.

The decrease in students' anxiety is complemented by the attitudinal evolution towards the chemistry laboratory, consolidating this space as a unique place for instruction, learning and evaluation, which allows improvement in cognitive, motor and memory skills.

This work consolidates as the first one in Latin America to apply a translated version of Spanish of Craig Bowen's chemistry laboratory anxiety instrument and relate it in a novel way in the particular context of a chemistry research group in secondary education. The translation of the instrument is adequate for the big majority of secondary and university chemistry laboratories in Latin America.

Finally, based on this experience, new research questions could be formulated related to a research group in physics, biology or mathematics or even that addresses all subjects in an integrated way under the area of science, or maybe, one that counts with a greater number of participants in other academic levels (primary, undergraduate, postgraduate) or contexts, for example, comparing public and private institutions or virtual versus face-to-face laboratory.

AUTHORS' CONTRIBUTIONS STATEMENTS

L.F.A.A. and E.G.P. conceived the presented idea. L.F.A.A. developed the theory, adapted the methodology to this context, created the models, performed the activities, and collected the data. L.F.A.A. and E.G.P. analysed the data. All authors actively participated in the discussion of the results and reviewed and approved the final version of the work.

DATA AVAILABILITY STATEMENT

Data used and analysed during the present study are in the authors' archives, the first author L.F.A.A. being in charge of their custody and consultation by the interested parties. Videos of the laboratory sessions, both face-to-face and virtual, are available in the drive folder: https://drive.google.com/drive/folders/15QOnxpqR9Wp7S8q8GH0PHH9AhoyeHCe4?usp=share_link

REFERENCES

American Chemical Society. (2018). *ACS Guidelines and recommendations for reaching middle and high school chemistry.* The American Chemical Society.

Beyer, K. (1991). Gender, science, anxiety and learning styles. *Sixth International Gender and Science and Technology (GASAT).* The University of Melbourne.

Bouras, N., & Holt, G. (2007). *Psychiatric and behavioral disorders in intellectual and developmental disabilities.* Cambridge University Press.

Bowen, C. (1999). Development and score validation of a chemistry laboratory anxiety instrument (CLAI) for college chemistry students. *Educational and psychological measurement, 59*(1), 171-185. https://doi.org/10.1177%2F0013164499591012

Chiarelott, L., & Czerniak, C. (1987) Speaking Out: Science Anxiety. *The Clearing House: A Journal of Educational Strategies, Issues and Ideas*, 60(5), 202-205, https://doi.org/10.1080/00098655.1987.9959323

Eddy, R. (2000). Chemophobia in the College Classroom: Extent, Sources, and Student Characteristics. *Journal of Chemical Education, 77*(4), 514-517. https://doi.org/10.1021/ed077p514

Galloway, K., Zoebede, M., & Stacey, L. (2016). Investigating Affective Experiences in the Undergraduate Chemistry Laboratory: Students' Perceptions of Control and Responsibility. *Journal of Chemical Education, 93*(2), 227-238. https://doi.org/10.1021/acs.jchemed.5b00737

Hernández Sampieri, R., Fernández Collado, C., & Baptista Lucio, P. (2014). *Metodología de la investigación.* McGraw Hill.

Hofstein, A., & Lunetta, V. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational Research*, *52*, 201-217.

Hofstein, A., Kipnis, M., & Abrahams, I. (2013). *Teaching Chemistry - A Studybook A Practical Guide and Textbook.* Sense.

Johnson, B., Onwuegbuzie, A., & Turner, L. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research, 1*(2): 112-133. https://doi.org/10.1177/1558689806298224

Kaya, E., & Cetin, P. (2012). Investigation of Pre-service chemistry teachers' chemistry laboratory anxiety levels. *International Journal on New Trends in Education and Their Implications, 3*(3), 90-98.

Keeves, J. P., & Morgenstern, C. (1992). Attitudes toward science: Measures and effects. In J. P. Keeves, *The IEA Study of Science III: Changes in Science Education and Achievement: 1970-1984* (pp. 122-140). Pergamon.

Kilic, D., Emsen, P., & Soran, H. (2011). Behavioral Intention Towards Laboratory Applications in Science Teaching. *Procedia - Social and Behavioral Sciences*, 416-420. http://doi.org/10.1016/j.sbspro.2011.11.079

Kuh, g., Kinzie, J., Buckley, J., Bridges, D., & Hayek, J. (2006). *What matters to student success: A review of the literature.* National Postsecondary Education.

Kurbanoglu, I., & Akim, A. (2010). The Relationships between University Students' Chemistry Laboratory Anxiety, Attitudes, and Self-Efficacy Beliefs. *Australian Journal of Teacher Education, 35*, 48-59. http://doi.org/10.14221/ajte.2010v35n8.4

Mallow, J. V. (1987). Science anxiety and gender. *Bulletin of Science, Technology y Society*, *7*(3-4):958-962. https://doi.org/10.1177/027046768700700389

Mallow, J., & Greenburg, S. (1983). Science anxiety and Science learning. *The Physics Teacher, 21*(2), 95-99. https://doi.org/10.1119/1.2341214

Mazzone, L. (2007). The role of anxiety symptoms in school performance in a community sample of children and adolescents. *BMC Public Health, 7*(1), 347. https://doi.org/10.1186/1471-2458-7-347

Ministerio de Educación Nacional. (2015). *Orientaciones para la construcción o ajuste en los establecimientos educativos del manual de normas de seguridad en los laboratorios de química y física.* MEN .

OECD. (2018). *OECD Reviews of School Resources: Colombia 2018.* OECD Publishing. https://doi.org/10.1787/9789264303751-en

Pintrich, P., & De Groot, E. (1990). Motivational and Self-Regulated Learning Components of Classroom Academic Performance. *Journal of Educational Psychology, 82*(1), 33-40.

Richardson, M., Abraham, C., & Bond, R. (2012). Psychological correlates of university students' academic performance: a systematic review and

meta-analysis. *Psychological Bulletin, 138*, 353-387. https://doi.org/10.1037/a0026838.

Rodríguez Portuguez, G. (2016). *Funciones ejecutivas, rasgos de personalidad y rendimiento académico en estudiantes universitarios de ciencias de la salud.* Ediciones Universidad de Salamanca.

Rummey, C., Clemons, T., & Spagnoli, D. (2019). The impact of several demographic factors on chemistry laboratory anxiety and self-efficacy in students' first year of university. *Student Success, 10*(1), 87-98. https://doi.org/10.5204/ssj.v10i1.1104

Tamayo Alzate, Ó., & López Rua, A. (2012). Las prácticas de laboratorio en la enseñanza de las ciencias naturales. *Revista Latinoamericana de Estudios Educativos, 8*(1), 145-166.

Ural, E. (2016, Abril). The Effect of Guided Inquiry Laboratory Experiments on Science Education Students' Chemistry Laboratory Attitudes, Anxiety and Achievement. *Journal of Education and Training Studies, 4*(4), 217-227. https://doi.org/10.11114/jets.v4i4.1395

York, T., Gibson, C., & Rankin, S. (2015). Defining and Measuring Academic Success. *Practical Assessment, Research & Evaluation, 20*(5). https://doi.org/10.7275/hz5x-tx03

APPENDIX 1

Laboratory sessions carried out in the research group.

No.	Name of the session	Date	Objective	Modality
1	Safety regulations in the chemistry laboratory.	27/02/20	Recognize safety standards and personal protective equipment in the chemistry laboratory. Application of pilot test of the instrument for the measurement of anxiety.	Face to face (F2F)

2	Cleaning and recognition of laboratory instruments and equipment.	05/03/20	Recognize the name and function of the different laboratory instruments and equipment. Apply the anxiety test for the first time.	Face to face (F2F)
3	Classification of chemical reagents.	12/03/20	Recognize and classify the chemical reagents available in the school laboratory according to their chemical functions.	Face to face (F2F)
4	Chemical functions and chemicals used at home.	25/06/20	Recognize chemistry as a science present in daily life, relating chemical substances commonly used in homes, their common and scientific name, and their chemical formula.	ICT mediated through Teams® and virtual lab tools.
5	Alkali and alkaline earth metals.	09/07/20	Delve into the subject of the physical and chemical properties of alkali and alkaline earth metals.	ICT mediated through Teams® and virtual lab tools.
6	Polymers.	10/09/20	Acquire the concept of polymers, their classification, their utility, and the environmental problem they pose.	ICT mediated through Teams® and virtual lab tools.
7	pH and titrations.	24/09/20	Acquire the concepts of acidity, basicity, indicators, pH and pOH.	ICT mediated through Teams®

			Understand what the titling process consists of and what it is for.	and virtual lab tools.
8	Ministry of Education Research event (Ondas 4.0 Lab): Contextualization workshop for students.	14/10/20	Contextualize the students in the ONDAS 4.0 LAB pilot program of the Ministry of National Education.	ICT mediated through Teams® and virtual lab tools.
9	Ministry of Education Research event (Ondas 4.0 Lab): Challenge definition.	15/10/20	Pose a research problem in understanding the context of the population. Collect information on the current state of the matter.	ICT mediated through Teams® and virtual lab tools.
10	Ministry of Education Research event (Ondas 4.0 Lab): Prototype development using the Internet of Things.	22/10/20	Devise and prototype a solution for the research problem, using concepts from chemistry and the internet of things.	ICT mediated through Teams® and virtual lab tools.
11	Chemical bonding and Lewis structures (using Chemsketch® software).	22/10/20	Acquire the concepts of chemical bonding, octet rule and Lewis structures.	ICT mediated through Teams® and virtual lab tools.
12	Chemical bonding and intermolecular forces.	04/11/20	Determine the relationship between chemical bonds and the properties of substances	ICT mediated through Teams® and

			(solubility and electrical conductivity). The student describes the reagents used, the procedure and the conceptual basis that supports this practice.	virtual lab tools.
13	School scientific project.	04/11/20 – 17/11/20	Propose a free-themed school scientific project with the knowledge acquired in the subjects of chemistry and pedagogy. Students in the research group lead the approach to the school project in groups with other students not belonging to the group. Apply the anxiety scale instrument a second time.	ICT mediated through Teams® and virtual lab tools.
14	Ministry of Education Research event (Ondas 4.0 Lab): Speak up.	20/11/20	Present the prototype solution of the research problem (Socialization before the other Normal Schools of the country). Find ways to implement the solution idea.	ICT mediated through Teams® and virtual lab tools.

APPENDIX 2

Chemistry Laboratory Anxiety Instrument translated and used in the classroom with the research group students.

Fecha de aplicación del test	

Estimado estudiante, por favor, lea bien antes de responder y califique cada ítem de la siguiente encuesta, teniendo en cuenta su opinión, con los siguientes criterios:
Totalmente en desacuerdo=TD
En desacuerdo= D
No opina = N
De Acuerdo = DA
Totalmente de acuerdo =TA

CUESTIONARIO:

	TD	D	N	DA	TA
Me siento intranquilo e inseguro cuando uso sustancias químicas durante el trabajo en el laboratorio.					
Cuando trabajo en el laboratorio de química me siento tranquilo al usar los equipos e instrumentos.					
Cuando me preparo para el laboratorio, me preocupa registrar los datos que se generarán.					
Cuando trabajo en el laboratorio de química, me siento nervioso trabajando con otros estudiantes.					
Me preocupa no tener tiempo suficiente para terminar el laboratorio.					
Cuando me preparo para el laboratorio de química, me preocupo sobre las sustancias químicas que usaremos.					
Cuando estoy trabajando en el laboratorio, me siento nervioso llevando a cabo los procedimientos requeridos.					
Me siento intranquilo e inseguro cuando registro datos durante la realización del laboratorio.					
Me siento cómodo trabajando con otros estudiantes en el laboratorio.					

Cuando estoy trabajando en el laboratorio, siento nervios del tiempo que tomará la práctica.					
Cuando estoy en el laboratorio, me siento cómodo estando cerca de sustancias químicas.					
Me siento intranquilo e inseguro cuando llevo a cabo un procedimiento de laboratorio.					
Cuando estoy trabajando en el laboratorio, me siento nervioso sobre el registro de los datos que necesitaré para llevar a cabo la experiencia.					
Me siento intranquilo e inseguro cuando trabajo con otros estudiantes durante el laboratorio.					
Cuando me preparo para el laboratorio, me siento preocupado sobre el tiempo disponible para hacer el experimento.					
Cuando estoy trabajando en el laboratorio de química, me siento nervioso de estar cerca de las sustancias químicas.					
Me siento intranquilo e inseguro cuando uso equipos e instrumentos durante la realización del laboratorio.					
Cuando trabajo en el laboratorio de química, me siento tranquilo registrando los datos necesarios.					
Cuando me preparo para el laboratorio, me preocupa trabajar con otros estudiantes.					
Estoy cómodo con el tiempo disponible para hacer el laboratorio.					