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EDUCATIONAL IMPACT OF EXPERIMENTATION IN NATURAL SCIENCES: A CASE STUDY AT THE ANDRÉS BELLO DISTRICT EDUCATIONAL INSTITUTION IN COLOMBIA

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Abastract. Results of an investigation that studies the impact of experimentation as a strategy that allows strengthening the acquisition of significant learning related to the area of Natural Sciences are presented. The case study is applied, selecting students from cycle II of the Andrés Bello District Educational Institution in Colombia. The sample had a total of 196 students and 9 teachers. To respond to the object of study, the following phases are developed. First, a diagnosis was developed by performing a pretest to the group of students, then 8 laboratory guides were applied that put the experimentation to the test; During these practices, participant observation was applied and at the end a socialization was made. Finally, a post test was carried out to analyze the learning obtained during the practices, proceeding to the triangulation of methods and test subjects. The results regarding the diagnosis show a lack of spaces and tools for experimentation; likewise, the students did not have internalized key concepts for their study cycle. However, they were motivated by the development of the guides, being able to show the understanding of the concepts worked in the laboratory. It is concluded that experimentation as an educational strategy benefits students at this age since, through exploration, it is easier for them to learn basic concepts. That is why it is suggested that the academic curriculum should give greater importance in time and space to the development of experimentation in Natural Sciences.

Keywords: experimentation, education, cycle II, Natural Science, learning.

IMPACTO EDUCATIVO DE LA EXPERIMENTACIÓN EN CIENCIAS NATURALES: ESTUDIO DE CASO EN LA INSTITUCIÓN EDUCATIVA DISTRITAL ANDRÉS BELLO EN COLOMBIA

Resumen. Se presentan resultados de una investigación que estudia el impacto de la experimentación como estrategia que permite fortalecer la adquisición de aprendizajes significativos relacionados con el área de Ciencias Naturales. Se aplica el estudio de casos, seleccionando estudiantes del ciclo II de la Institución Educativa Distrital Andrés Bello en Colombia. La muestra contó con un total de 196 estudiantes y 9 docentes. Para dar respuesta al objeto de estudio, se desarrollan las siguientes fases. Primero, se desarrolló un diagnóstico mediante la realización de un pretest al grupo de estudiantes, luego se aplicaron 8 guías de laboratorio que pusieron a prueba la experimentación; durante estas prácticas se aplicó la observación participante y al finalizar se hizo una socialización. Por último, se realizó un post test para analizar el aprendizaje obtenido durante las prácticas, procediendo a la triangulación de métodos y sujetos. Los resultados en cuanto al diagnóstico evidencian una falta de espacios y herramientas para la experimentación; asimismo, los estudiantes no tenían interiorizados conceptos claves para su ciclo de estudio. Sin embargo, se mostraron motivados con el desarrollo de las guías, pudiéndose evidenciar la comprensión de los conceptos trabajados en el laboratorio. Se concluye que la experimentación como estrategia educativa beneficia a los estudiantes en esta edad ya que, a través de la exploración les resulta más sencillo aprender conceptos básicos. Es por ello que, se sugiere que el currículo académico debe dar una mayor importancia en tiempo y espacios al desarrollo de la experimentación en Ciencias Naturales.

Palabras clave: experimentación, educación, ciclo II, Ciencias Naturales, aprendizaje.

Introduction

The construction of scientific thinking is one of the most important pillars expected to be developed during the primary education stage. In this sense, the educational system is ideally designed to strengthen children's investigative intuition in Natural Sciences, and it is expected that they will be able to apply what they have seen in class throughout their daily lives. In contrast to this, the traditional way of teaching from which students are considered as recipients in which knowledge is deposited and not as beings capable of interacting with the world, generates a rupture and a break in the development of that intuition and the application of the concepts in their daily lives (Jappe et al., 2019).

In several Colombian educational institutes, this form of teaching still has a great prevalence and, therefore, the imaginative and experimental capacity of students is often overshadowed, even, the value of theory and conceptualization usually has a greater weight than experimentation.

In this order of ideas, García and Estany (2010) mention that, although there is a clear differentiation between theoretical science and experimental science, they are not disjointed practices, but, on the contrary, they are mutually necessary. However, in conventional educational classrooms, practice has been cultivated as a subsidiary activity of theory, i.e., it is used for verification and of course, this is a problem that detracts protagonism, importance and above all life from experimentation (García and Moreno, 2020; Quiroz and Zambrano, 2021). In view of this situation, it is proposed to implement strategies that do not detract from the importance of theoretical knowledge, but are aimed at eliminating the gap according to which experimentation is at the service of theory (García and Moreno, 2020) and provide benefits in the teaching-learning process.

The role of experimentation in learning

Authors such as Bascopé and Caniguan (2016) analyze the Chilean case and state that one of the most powerful reasons for including experimentation in science classes is that it allows a dialogue between scientific fundamentals and the students' everyday elements, thus making learning much more attractive and motivating students.

Fonseca and Gamboa (2017), professors at the University of Las Tunas (Cuba), adduce other reasons why a review of the methodology used in science teaching, which underlies the curricula not only in Cuban education but also in Latin America, is necessary. These authors point out that the curricular revision is pertinent to respond to the new demands of science and technology in order to prepare young people to be the main actors in the social changes that are taking place. Also, Hernández and Villavicencio (2017), reflecting on the necessary changes in science education in Mexican youth, state that the application of novel techniques such as experimentation is a step that must be taken to increase motivation levels, in order to create solid learning environments, which facilitate the construction of knowledge.

Jappe et al. (2019) expose that experimentation is an element of vital relevance for the teaching of Natural Sciences in basic education, mainly regarding phenomena of a chemical nature. The authors adopt the experimental approach through the playful construction, such construction allows strengthening and developing a transformation in teaching, allowing students to better acquire knowledge, since they relate it quickly with ideas.

Teaching Natural Sciences in Colombia

The Colombian educational scenario is no stranger to these discussions, and various researchers have outlined the reasons why experimentation could be effective. For example, Bejarano (2015), from the National Pedagogical Institute, reported what was pointed out in the preceding lines regarding the need to relate learning in science classes with elements of the everyday life of young people, as one of the most powerful causes to consider experimentation as a strategy in the educational framework.

In the Colombian case, the curriculum is divided by academic cycles; in the first cycles, the teaching of Natural Sciences involves a cohesion of knowledge and information according to Physics, Chemistry, Biology and Geology, among others, which may vary according to the management of the Institutional Educational Plan (Secretaría Distrital de Educación, 2011). According to the proposals of the Ministry of National Education, education in Natural Sciences in the initial and basic stages seeks that students receive their first experiences in the scientific world, based on the stimulation and development of a theoretical approach applied to these purposes. In general terms, experimentation has always been part of the Natural Sciences classes, the real problem is that it has not been considered as an instrument to promote and strengthen scientific knowledge.

Main obstacles to experimentation in basic education

First, Meneses et al. (2016) undertook a study aimed at young students in Nicaragua, and managed to verify that one of the major impediments to the incorporation of experimentation as an educational strategy, was the lack of equipment in laboratories. However, they point out that this should be seen as a challenge to which teachers should respond with creativity and innovation, since research skills and the teaching of the scientific method do not inevitably require a laboratory.

On the other hand, Vázquez and Manassero (2017) disclosed a study applied in Spain in which some limitations similar to those already seen are demonstrated. The first limitation they report is that, although the curriculum enables experimentation as a fundamental axis in the teaching of Natural Sciences, it is not an aspect that is organized, in fact, they include it in a dispersed way and there is no clarity about this. On the other hand, they found skepticism on the part of Spanish teachers, who insist on implementing traditional practices because they consider that those focused on innovation are very complex and students are not able to understand them.

The teaching of Natural Sciences in early childhood education has great challenges and transformations, which creates a general framework oriented to the understanding of science as a theoretical-practical interaction. Teachers are currently undergoing the didactic need to modify their teaching guidelines, which are focused on leaving aside the traditional passive view of the student, making him/her an active subject in constant interaction with the phenomena of the world around him/her. Thus, the learning-teaching of Natural Sciences requires new practices and didactic strategies oriented towards the interaction between knowledge and experimentation. That is why, in this study we propose to analyze the impact of experimentation as a strategy that allows strengthening the acquisition of significant learning related to the area of Natural Sciences.

Creative Learning Environments for Natural Sciences

Information and Communication Technologies (ICT) play a really important role in the purpose of reconfiguring the teaching and learning practices of students in the area of Natural Sciences, however, as it has been evidenced, the context of the population that is the sample of this research does not allow these practices to be developed, since the access of this population to technological means is quite limited.

In this sense, the author proposes the development of some activities that can focus on the creativity and innovation of the students' knowledge, without having to contemplate the use of the so-called ICTs:

- Provide students with contextual problems related to life, earth, or physical and chemical sciences.
- Contextualize curriculum content according to student needs.
- Evaluate learning according to the teaching context.
- Employ strategies for the discovery of scientific knowledge.
- Apply the experimental process in learning scenarios.
- Apply problem-based learning activities (PBL) according to knowledge scenarios.
- Use autonomous and collaborative learning.
- Discussions and debates.

Method

Design

In order to identify the impact of experimentation as a strategy that allows strengthening the acquisition of significant learning related to the area of Natural Sciences, we propose to work with students of Cycle II (third and fourth grade) of the Andrés Bello District Educational Institution.

The case study is chosen since, according to Soto and Escribano (2019) it is a strategy or tool widely used in research in "human sciences" with a double application: for learning and as a method of inquiry because it allows obtaining much deeper data from small groups and with similar characteristics. It also makes it possible to situate the research in a socio-educational context, with spatio-temporal and curricular coordinates. The research is based on a mixed research approach, using both qualitative (participant observation, workshops and narrative records) and quantitative (questionnaires, pretest and posttest) techniques.

Taking into account the objectives set, 4 fundamental stages were consolidated for the collection of data in correspondence with these objectives.

- Preliminary diagnosis, in order to identify initial needs. This was done by applying a pretest to observe the students' previous knowledge.
- Design of the experimentation, based on the initial needs and aimed at favoring significant learning after the intervention. In this sense, a total of 8 laboratory guides were built based on the topics that the students work on throughout Cycle II, responding to the curriculum of the stage.
- Application of the designed guides, in order to intervene with the group to promote educational innovation and generate a more significant knowledge. The intervention time was extensive (6 months). Each session had two hours of work for two days, resulting in 4 hours of work for the execution of each guide. During the laboratory practice, a participant

observation was also carried out by means of an observation guide, where key professionals were involved.

- Final diagnosis, in order to verify the improvements obtained after the application of the guides. This phase involves the application of a post-test to demonstrate the changes in relation to the first test applied and to observe the nature of the learning achieved.

Participants

Regarding the sample of students, 100% of the students enrolled in Cycle II of the Andrés Bello Educational Institution, in the third and fourth grades, were selected. Specifically, 6 groups were selected, 3 in third grade, which are divided into three groups: 301, 302 and 303; and three in fourth grade, which are also divided into three groups: 401, 402, 403, thus participating in the study a total of 196 students. Regarding the sample of teachers and experts, a total of 9 professionals were intentionally selected. This selection is due to the fact that they are teachers of the subject under study at the Andrés Bello Educational Institution in the city of Bogotá (Colombia), as well as specialists with ample experience in the teaching practice of the Natural Sciences area..

Instruments

Instruments and techniques of a mixed quantitative and qualitative nature are combined, in coherence with the methodological approach selected to respond to the object of study. Specifically, in accordance with the research phases described above, the following are applied::

- Questionnaires (pre-test, post-test): A test is designed ad hoc to recognize and identify the knowledge acquired by the students. The questions they contain are related to the topics they are working on according to the curriculum of their cycle.
- Laboratory guides: in each of the laboratory practices, the pedagogical strategy of forming collaborative teams was proposed; the course was divided into 4 subgroups. In most of the practices, each subgroup had 8 students. These guides were adapted according to the needs identified in the students, in order to promote a more significant learning after the experimentation.
- Observation guide, applied during the realization of each laboratory practice. This instrument considered the following key dimensions: a) student motivation; b) academic performance; c) learning acquisition; and, d) teacher attitude and conformity with the activity.
- At the end of each practice, a socialization of the activity was carried out, which resulted in narrative information collected in the teacher's diary.

Participants

Data analysis was carried out by mixed procedures, according to the nature of the information obtained. The pretest and posttest analysis (quantitative information) was carried out using SPSS, applying descriptive statistical techniques to identify frequencies and averages. As for the qualitative information (observation and socialization guides), this information was analyzed taking into account the opinions and behaviors that were most repeated by the students, identifying relevant discourses and narratives that informed about the educational impact of the experimentation. Considering its meaning, the qualitative information was analyzed by establishing a system of categories and content analysis.

Results

The main findings obtained in the research are presented, sequenced in coherence with the phases followed in the research.

Initial diagnosis: determination of needs in the teaching of Natural Sciences

The results obtained in each of the questions asked during the pretest are shown below. As can be seen in Figure 1, only 11% of the total number of students got their answers right, while 89% opted for the second option in which the skull and thorax were identified as important parts of the human body.

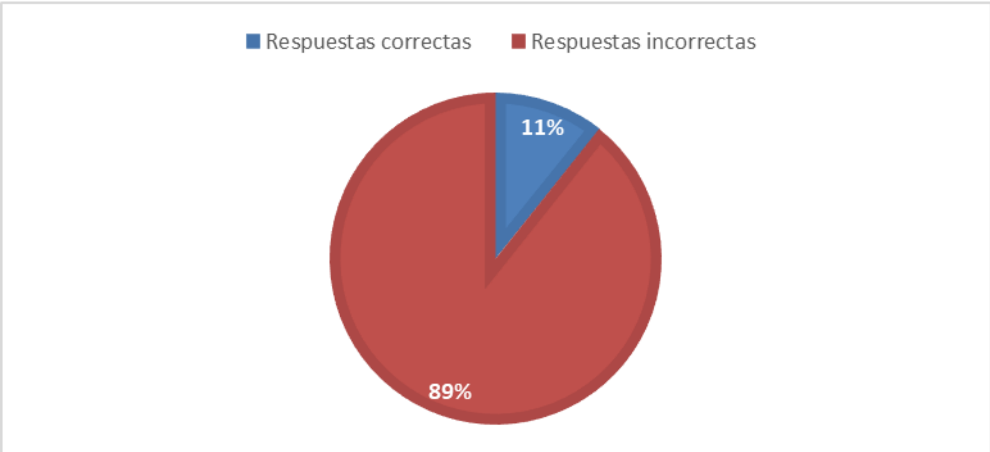


*Figure 1***.** Question 1. Parts of the body.

Note: Own elaboration.

Considering the answers to the second question, only 21% of the students indicated the correct answer: "cells", and 79% leaned towards the answer referring to organs (Figure 2).

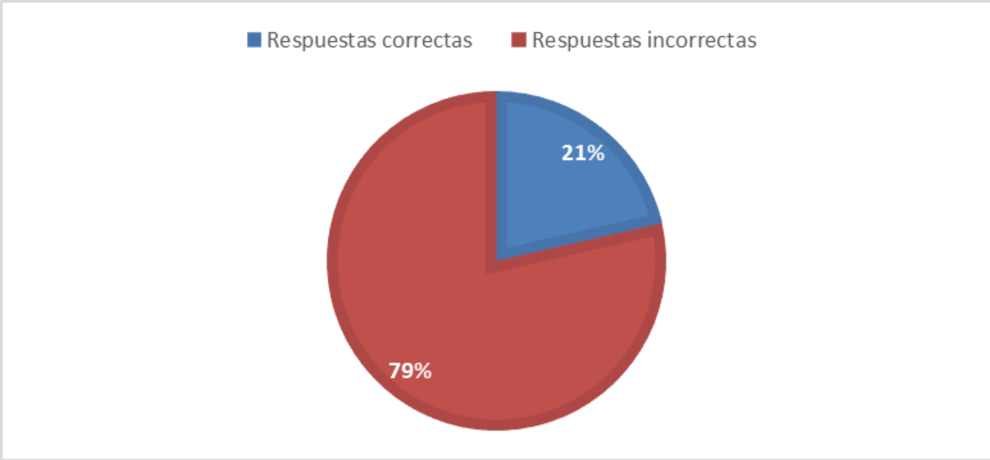


*Figure 2***.** Question 2. The human body is composed of millions of ..

Note: Own elaboration.

Figure 3 shows how the correct answer to the third question of the test was "organs", however, only 1% of the students chose this answer and 99% chose to answer "systems".

*Figure 3***.** Question 3. What makes up a set of tissues of the same kind?

Note: Own elaboration.

In the next question (4), we aimed to observe the students' memorizing capacity. According to the data presented, only 7% of the total number of students got the correct answer. The remaining 93% answered that the thorax is composed of 12 ribs, followed by the option of 14 and only a few considered that 28 was the correct number (Figure 4).

*Figure 4***.** Question 4. Number of ribs of the thorax.

Note: Own elaboration.

In relation to question 5, only 7% were able to adequately identify the parts of a plant, while 93% showed a low knowledge of plants (Figure 5).

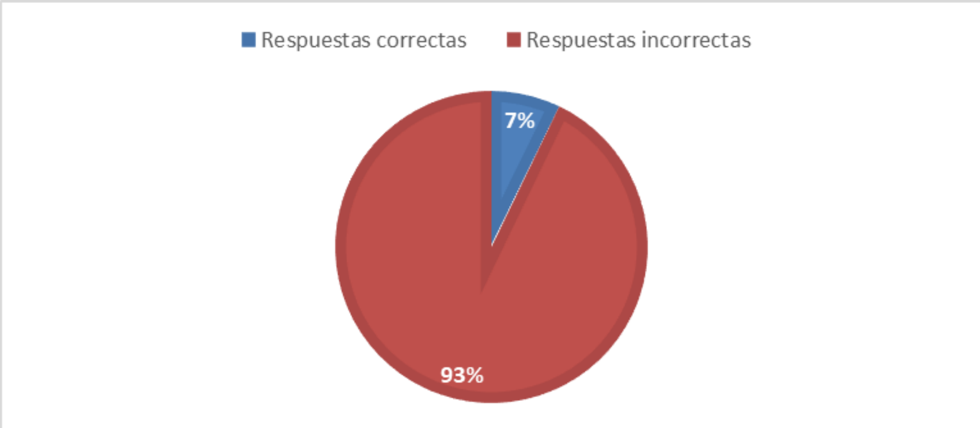


*Figure 5***.** Question 5.Parts of a plant.

Note: Own elaboration.

Regarding questions 6 and 7, these were asked in an open-ended manner. Question 6 asked students to explain 3 statements about plants and question 7 asked them to describe the vital activities performed by living beings.

Regarding the sixth question it was possible to evidence that students answered in a general way, without stopping in each one of the statements. This showed the students' low comprehension of the statement of the question. Some examples of answers are shown in Figure 6:

"- Las plantas nos dan el oxígeno.
- Las plantan se alimentan por la raíz y nos dan oxígeno.
- Sí, toman agua por la raíz, además producen oxígeno, no sé."

*Figure 6***.** Fragments of answer to the sixth question.

Note: Own elaboration.

In addition, according to their answers, it was possible to confirm their low knowledge regarding the photosynthesis process. Regarding the seventh question, the students identified some of the vital functions of living beings; however, an adequate knowledge of clear terms about these was not identified and in addition many of them identified only three and in some cases only one vital function was mentioned. This can be evidenced in some examples of discourses in Figure 7:

"- Camina, respirar, tiene hijos.
- Comer, dormir, hablar.
- Comer, respirar y dormir."

*Figure 7***.** Fragments of answer to question seven.

Note: Own elaboration.

The results were more similar for question 8. While 54% got the answer right, the remaining 46% showed no knowledge or mastery of the subject (Figure 8).

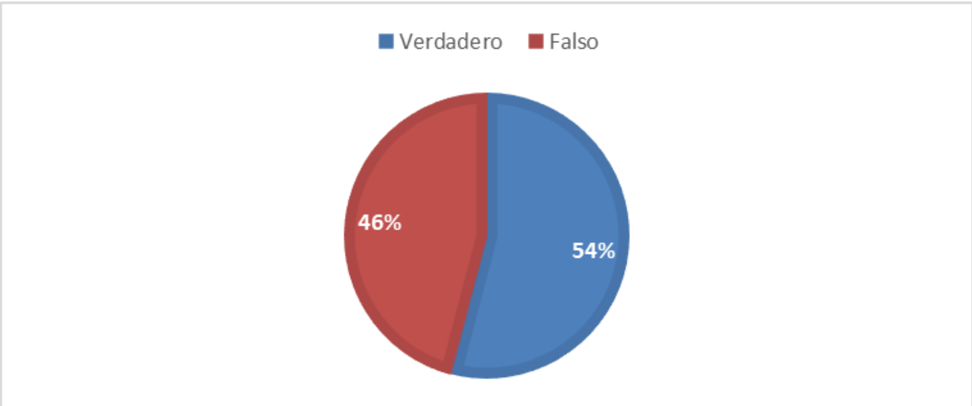


*Figure 8***.** Question 8. Statement on the definition of matter and some examples.

Note: Own elaboration.

If we look at questions 9 and 10 (Figures 7 and 8), it can be seen, respectively, that the majority of students (94%) were wrong in answering "false". Consequently, only 6% answered correctly. In the case of question 9, 24% of the students selected the correct option; however, the majority (76%) made a mistake on this point.

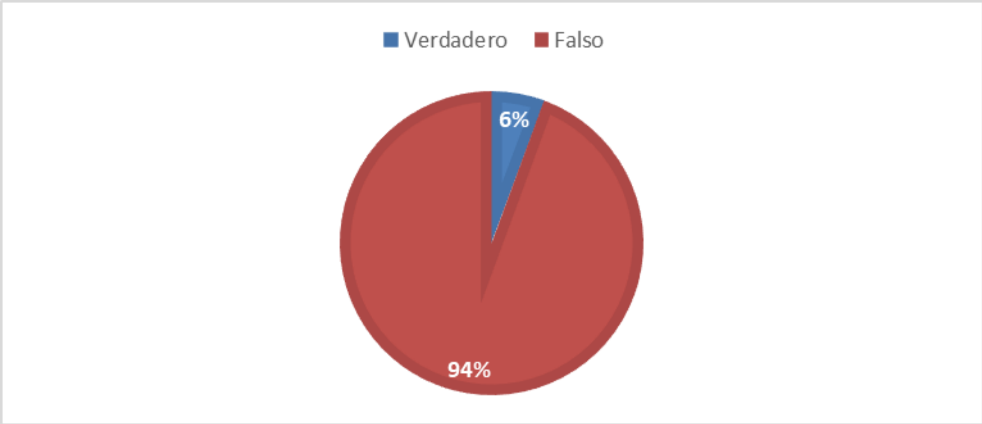


*Figure 9***.** Question 9. Statement: Liquids change shape depending on the container that holds them.

Note: Own elaboration.

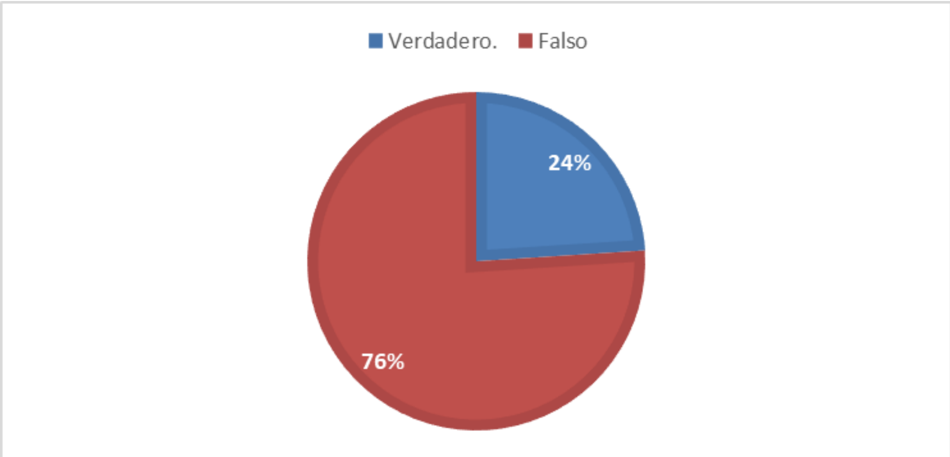


*Figure 10***.** Question 10. All bodies occupy a place in space.

Note: Own elaboration.

In the case of question 11 (Graph 9), only 9% answered correctly, while 91% did not get their answers right.

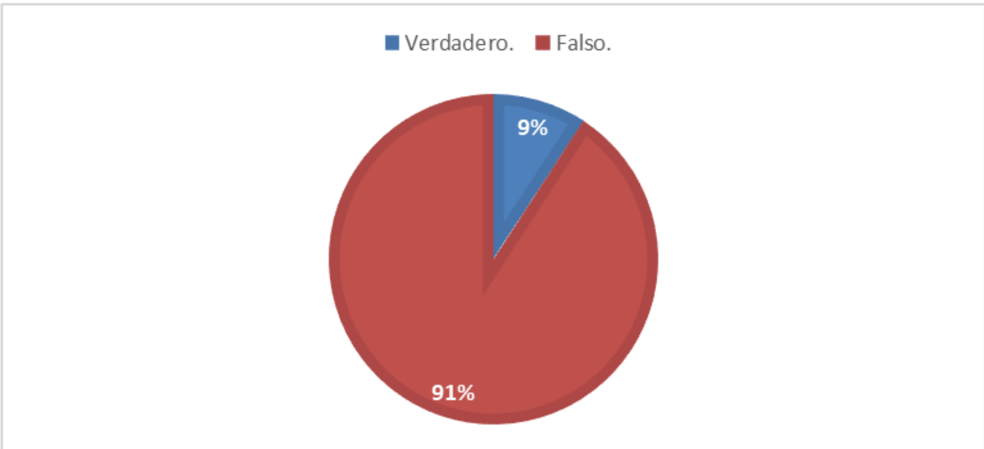


*Figure 11***.** Question 11. Gaseous bodies maintain neither shape nor volume.

Note: Own elaboration.

Question 12 was formulated as an open response and students were asked about two differences between living and inert beings. The answers in this case showed an apparently clear prior knowledge; however, the handling of key words is deficient and shows the need to enrich this knowledge. Below are some examples of answers (Figure 12) that show these interpretations:

"- Los seres vivos se mueven, los inertes no se mueven.
- Los seres vivos comen los inertes no comen.
- Seres vivos respiran los otros no hacen nada.
- Ser vivo come, ser inerte no come."

*Figure 12***.** Fragments of answer to the twelfth question

Note: Own elaboration.

Finally, question 13 was also an open-ended question based on an image of a pot of boiling water. The question was oriented towards the identification of the different states of matter; however, students answered only the process they observed in the image. Several students recognized evaporation as part of the transformation processes of matter. Even so, some students used the word "heating" to define what was happening in the image; that is, they do not have a clear understanding of the category of matter. As an example, some of the students' answers are shown in Figure 13:

"- El agua se está calentando.
- El agua se evapora.
- Se está evaporando el agua.
- Evaporación."

*Figure 13***.** Fragments of answer to the thirteenth question.

Note: Own elaboration.

Figure 14 summarizes the overall performance of the students who participated in the pretest.

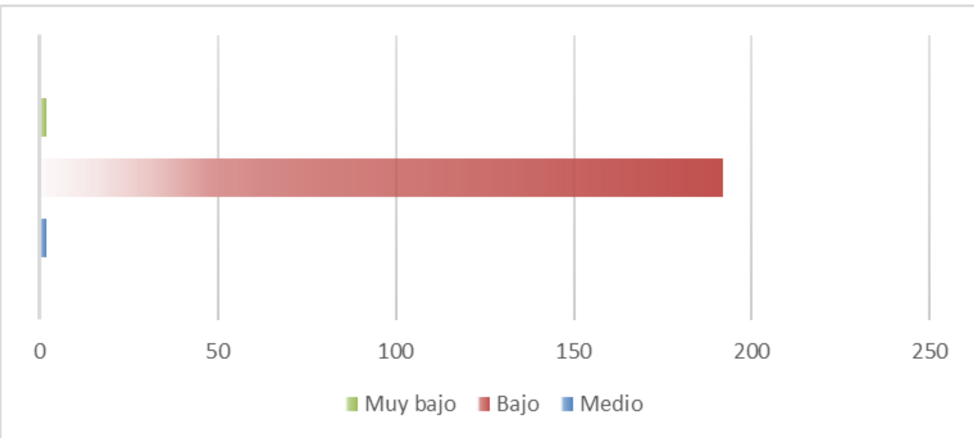


*Figure 14***.** Overall student performance at pretest time.

Note: Own elaboration.

Taking into account these initial diagnostic results, it is possible to affirm that there are learning needs in terms of key concepts such as the conformation of tissues and organs, plant processes and the different states of matter. Based on these identified needs, a series of experimentation guides are proposed.

Application of the laboratory guides: students' observations and comments

After diagnosing the knowledge and general situation of the students regarding the subject of Natural Sciences, we proceeded to the design and application of the proposed guides that responded to the previously identified needs. An observation guide was used in the application process, presenting the general results of this process.

In the design phase, the guides were elaborated taking into account the needs presented by the students. Likewise, an attractive presentation was chosen, the experiments should not be too complex and the topics to be covered should be applied in everyday life. Below is a summary of the guides and the aspects to be observed in each practice:

Table 1

Summary of the guides worked on.

Nombre de la guía	Tema	Objetivo	Aspectos a observar
El verde que alimenta	Fotosíntesis y coloración de las plantas.	Comprender el término de fotosíntesis y la coloración de las plantas.	¿Cómo reaccionan los y las estudiantes frente a las actividades propuestas? ¿cómo interactúan frente al procedimiento realizado para reconocer por qué las plantas son verdes y otras no? ¿qué comentarios hacen cuando realizan la experiencia del proceso de la fotosíntesis? ¿qué hacen respecto al procedimiento que realizaron?
¡Frutas color café!	Cambios en las frutas con la exposición a diferentes procesos.	Definir el término "oxidación" y explicar por qué aparece un color café a algunas frutas después de cortarlas o cuando sufren magulladuras.	¿Cómo reaccionan los y las estudiantes frente a las actividades propuestas? ¿cómo interactúan frente al procedimiento realizado para reconocer por qué aparece el color café en algunas frutas después de cortarlas o cuando se magullan? ¿qué comentarios hacen cuando realizan la experiencia de reconocer el fenómeno de la oxidación y cómo prevenirlo? ¿qué hacen respecto al procedimiento que realizaron?
Vamos a descubrir: ¿cómo es el sistema muscular?	Formación de los polímeros.	Explorar las características de los polímeros y cómo están formados.	¿Cómo reaccionan los y las estudiantes frente a las actividades propuestas? ¿cómo interactúan con la mezcla de reactivos para obtener el polímero? ¿qué comentarios hacen sobre el producto final que se propuso elaborar? ¿qué hacen con el producto obtenido?
Vamos a descubrir los secretos ocultos en el mundo de la saliva	Las enzimas de la saliva.	Explorar los componentes de la saliva y aportar diferentes explicaciones a cómo se forma y dónde se produce en el cuerpo humano.	¿Cómo reaccionan los y las estudiantes frente a las actividades propuestas? ¿cómo interactúan frente al procedimiento realizado para reconocer la función de la saliva en el proceso de la digestión? ¿qué comentarios hacen sobre la coloración y decoloración que la docente les muestra y que propuso elaborar? ¿qué hacen respecto al procedimiento que realizaron?
Vamos a descubrir los estados de la materia	Diversos cambios en la materia.	Explorar en diversas situaciones cotidianas los estados y cambios de estado de la materia.	¿Cómo reaccionan los y las estudiantes frente a las actividades propuestas? ¿cómo interactúan con las situaciones cotidianas sobre estados y cambios de estado de la materia? ¿qué comentarios hacen sobre situaciones cotidianas de estados y cambios de la materia que se propuso elaborar? ¿qué hacen respecto al experimento propuesto?
Vamos a observar ¿cómo es una célula animal?	Observación de la célula animal (frotis del interior de la mejilla y tejido sanguíneo).	Explorar las características de la célula animal y aportar diferentes explicaciones a las observaciones realizadas a la célula animal.	¿Cómo reaccionan los y las estudiantes frente a las actividades propuestas? ¿cómo interactúan con las observaciones realizadas del tejido sanguíneo y del frotis de la mejilla? ¿qué comentarios hacen sobre el montaje del frotis al interior de la mejilla y del tejido sanguíneo que la docente les muestra y que les propuso elaborar? ¿qué hacen respecto a las células que observan?
Vamos a observar ¿cómo es una célula vegetal?	Observación de la epidermis de la cebolla cabezona.	Explorar las características de la célula vegetal y aportar diferentes explicaciones a las observaciones realizadas a la célula vegetal.	¿Cómo reaccionan los y las estudiantes frente a las actividades propuestas? ¿cómo interactúan con las observaciones realizadas del tejido epidérmico de la célula vegetal? ¿qué comentarios hacen sobre el montaje de la epidermis de la cebolla cabezona que la docente les muestra y que les propuso elaborar? ¿qué hacen respecto a las células que observan?
Vamos a descubrir la composición de la materia	Descomposición de la sal	Explorar en diversas situaciones la descomposición de la sal.	¿Cómo reaccionan los y las estudiantes frente a las actividades propuestas? ¿cómo interactúan con la práctica de la descomposición de la sal? ¿qué comentarios hacen sobre la descomposición de la sal? ¿qué hacen respecto al experimento propuesto?

Note: Own elaboration.

After 6 months of application of the didactic guides, process information is obtained through observation with the support of the participating teachers and experts. Thus, the results of the observation and socialization with the students are presented below.

Regarding the practical guide "The green that feeds", the group was interested throughout the practice and there were no major problems in organizing the teams and dividing the activities. What they liked the most was to observe the color change in the porous paper of the experiment. The most difficult thing was to understand the name of the terms used, their origin and etymology. In addition, they considered that they wanted to try to do the experiment themselves with their own materials. The term that attracted the most attention was that of chlorophyll and the possibilities of pigmentation of many plants and flowers present in nature.

Regarding the practical guide "Coffee-colored fruits", the students are adapting more and more to the type of collaborative work, however, the formation of small groups implies for the teacher a longer explanation time. On the other hand, the students understood that oxidation is a chemical reaction and what they liked the most was to see the contrast of each piece of apple in each plastic cup when different substances were added to it, which configured its oxidation processes.

Additionally, it was important for them that the teacher let them manipulate the experiment in each case. The term that generated the most doubts was melanin, how it is produced and where, and finally, the most recurrent question was why only some fruits oxidize and others do not.

In the case of the practical guide "Let's discover: what is the muscular system like?", there were more interruptions, perhaps due to the number of students. However, most of them understood that many things around them are composed of polymers, as well as the human body; in addition, they learned how to make a polymer in the laboratory. This last point was what they enjoyed the most, as they were able to manipulate a polymer they created themselves. The most difficult part was the order established for the activity: one group had to wait for another to form their polymer, which made the students impatient.

In the practical guide "Let's discover the secrets hidden in the world of saliva", again the explanation to each group made the other students impatient, so it would be interesting to propose some complementary activity during this waiting time. On the other hand, the group learned how to test for the presence of enzymes in saliva; they also recognized the importance of saliva and chewing for digestion. One of the major difficulties was to understand the concept of amylase and they stated that there are some terms that are not easy to remember, but they manage to understand the process in a general way.

As for the practice "Let's discover the states of matter", the group showed interest in the activities of boiling and making cosmetic soap. The most difficult thing for some of them was the limited participation, due to the disposition of materials in each work group. Additionally, doubts were generated around the states of matter, especially the verification of sublimation and reversive sublimation changes.

Regarding the practice "Let's observe how an animal cell looks like", participation was high, there is astonishment when seeing the cells inside the cheek, likewise when seeing the blood tissue and how its cells move. The use of the microscope represented a great interest on the part of the group. The teacher concludes that the class time should be one block or more so that everyone can make observations and close the laboratory practice.

On the other hand, in the practice "Let's observe what a plant cell looks like", the use of the microscope allowed them to know in a real way the hexagonal shape that plant cells have and the different parts that compose them. What everyone liked the most was being able to manipulate the microscope and make assemblies. The most difficult part was the number of students, which made it difficult for each one to have a personal experience or for it to be delayed. Additionally, some students stated that they could not clearly see all the organelles that make up the plant cell.

Finally, in the practice "Let's discover the composition of matter", the students stated that they were able to learn more about the composition of salt and were able to understand that there are various compounds present in everyday life. What most caught their attention was to see how to light a light bulb in a non-traditional way. The most difficult thing in this case was that everyone wanted to participate and manipulate the experiment; however, since electric current was present, the teacher had to take special care in the socialization process.

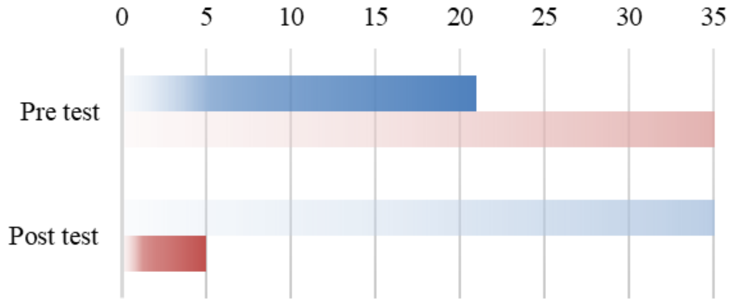
In general, the practices had certain particularities that depended mainly on the complexity of the experiments and the material used; however, a positive aspect is that in most cases the students were intrigued and wanted to participate. With the presentation of the results of the practical exercises, let us now look at the results of the post-test.

Comparison of pre-test and post-test results

Comparison of pre-test and post-test results

The last part of the research was the realization of a post-test to demonstrate if the concepts applied during the practices had really been learned and if the experimentation had an educational impact. Consequently, we are not going to refer to each of the results per question but to the comparison between these results and the results of the pre-test.

Regarding the first question on the parts of the body, the students' performance was positive, reaching 97%, which marks a significant difference with respect to the results obtained in the pretest application, as can be seen in Figure 15:

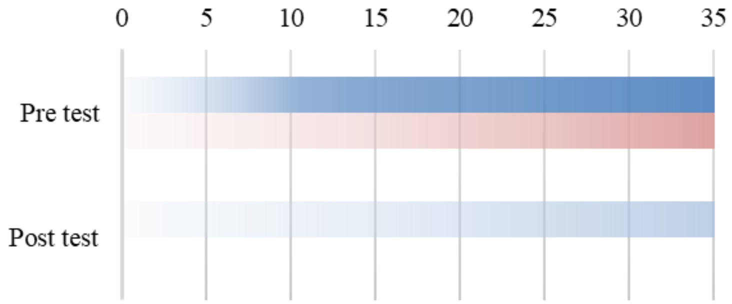


	Post test	Pre test
Respuestas correctas	191	21
Respuestas incorrectas	5	175

*Figure 15***.** Comparison between pre- and post-test first question.

Note: Own elaboration.

Now, in the second question, regarding the composition of cells in the human body, the students showed a favorable performance and none had an incorrect answer. When analyzing the results of the post-test (Figure 16), it can be seen that 100% of the population had a clearer understanding of the statement and were able to respond adequately to the formulation:



	Post test	Pre test
Respuestas correctas	196	42
Respuestas incorrectas	0	154

*Figure 16***.** Comparison of pre- and post-test second question.

Note: Own elaboration.

In the third question where the students are asked again about what makes up a set of tissues of the same class, only 4% of the students were wrong in their answers, the contrast between the pretest results is evident (Figure 17) and shows a significant improvement in the students' understanding of the concept of the tissues of the human body. However, it is necessary to continue working with this concept in order to consolidate the knowledge of all students:

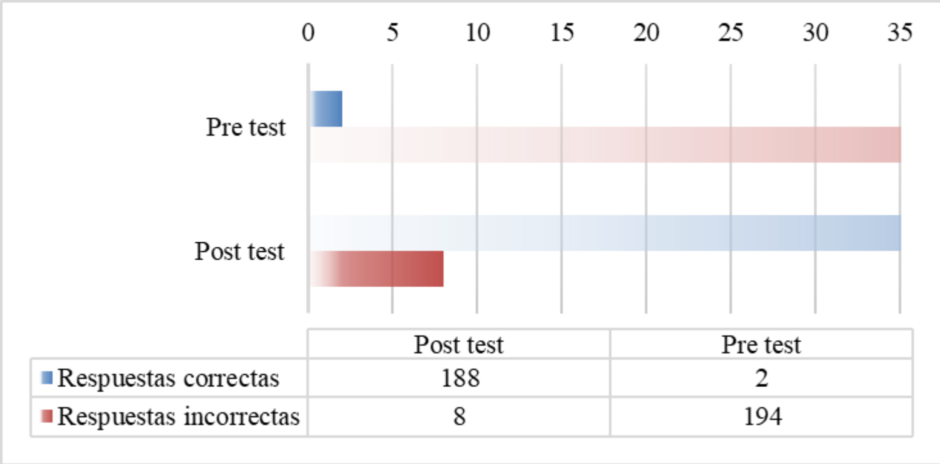


*Figure 17***.** Comparison pre and post test third question.

Note: Own elaboration.

In this order of ideas, and continuing with the subject of the composition of the human body from its different systems, the students were asked about the ribs that make up the thoracic cage. In this case, 92% of the students significantly improved their appreciation of the evaluated point, a fact that contrasts with the results of the pretest (Figure 18), where the students' deficiencies in the knowledge of the human body and its parts could be seen.

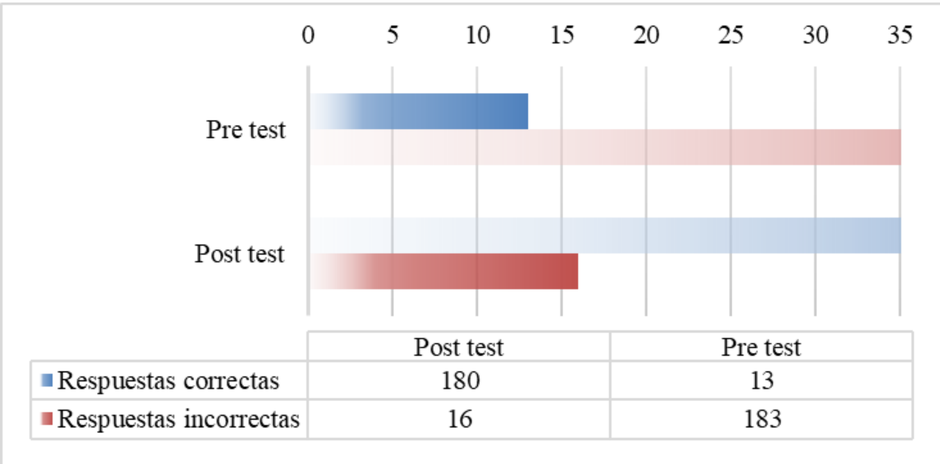
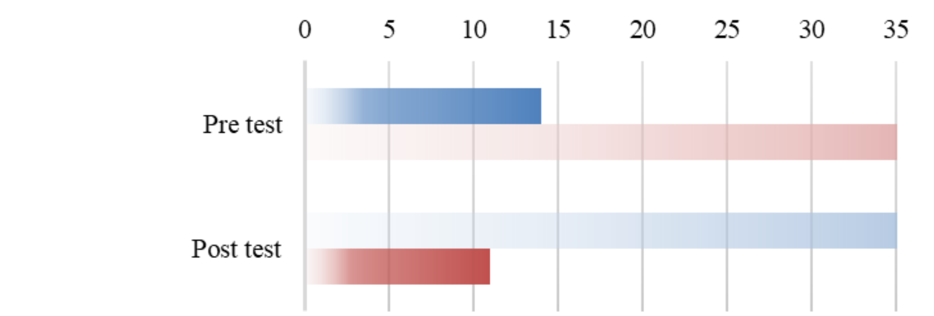


*Figure 18***.** Comparison pre and post test fourth question.

Note: Own elaboration.

The fifth question was focused on the parts of the plant; the post-test results show that only 6% of the total number of participants made a mistake in their answer, so most of the students, that is, 94% got it right in identifying the parts of a plant, making an accurate and appropriate use of the corresponding lexicon for this case.



	Post test	Pre test
Respuestas correctas	185	14
Respuestas incorrectas	11	182

Figure 19. Comparison pre and post test fifth question

Note: Own elaboration.

The sixth question was posed with an open response as mentioned initially, with the intention of knowing the way in which the students expressed their ideas and knowledge. A particular fact observable in the students' answers is that this time they did understand the statement in a more complete way, for this reason, of the three statements mentioned, the students were able to develop each of the ideas expressed, evidencing an adequate and sufficient knowledge of the photosynthesis process and the importance of plants in the production of oxygen. Some of the answers are shown in Figure 20:

> "- A) las plantas si elaboran su propio alimento gracias a la fotosíntesis. B) las plantas purifican el aire por qué ella recoge el CO2 y lo transforma en oxígeno. C) no por qué la fotosíntesis sólo se produce con presencia de la luz del sol.
>
> - Las plantas purifican el aire ya que nos dan el oxígeno por el proceso de la fotosíntesis pero requieren agua y la luz del sol.
>
> - Mediante el proceso de la fotosíntesis las plantas elaboran su alimento y producen oxigeno que ayuda a purificar el aire"

Figure 20. Fragments of answer to the sixth post-test question.

Note: Own elaboration.

Complementary to the above, the seventh question was formulated around the vital functions of living beings. In this regard, the activities identified as vital in living beings were mentioned in some cases as vital functions and more than 4 of these were satisfactorily identified, which was not the case in the pretest when only two or three were adequately identified. Some of the responses are shown in Figure 21:

" - Comer, tomar agua, respirar, dormir, tener hijos con la reproducción.
- Nutrición, respiración, excreción, reproducción.
- Nutrición, circulación, respiración, excreción."

*Figure 21***.** Answer fragments of the seventh post-test question.

Note: Own elaboration.

Regarding the eighth true-false question where a statement was made about the subject, 98% of the students answered correctly and only 2% made a mistake (Figure 16). Meanwhile, in the ninth true-false question where a statement was made regarding liquids, 94% of the students answered correctly during the post-test application (Figure 22).

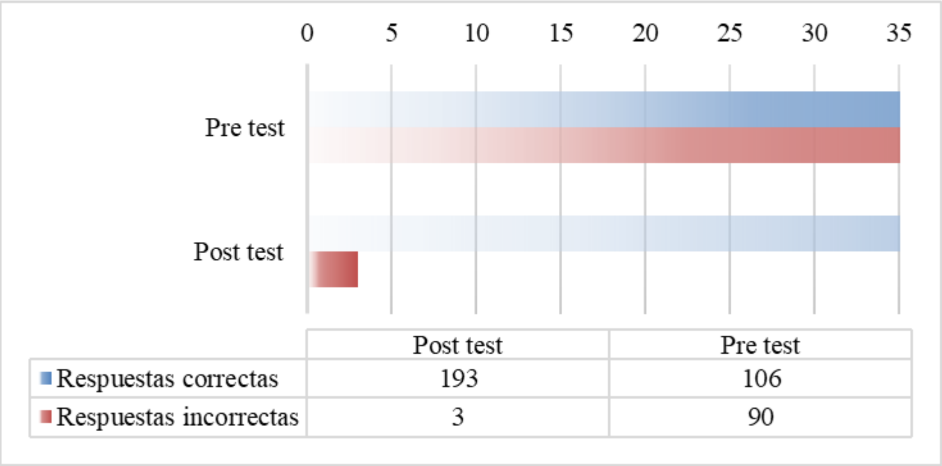


*Figure 22***.** Comparison pre and post test eighth question.
Note: Own elaboration.

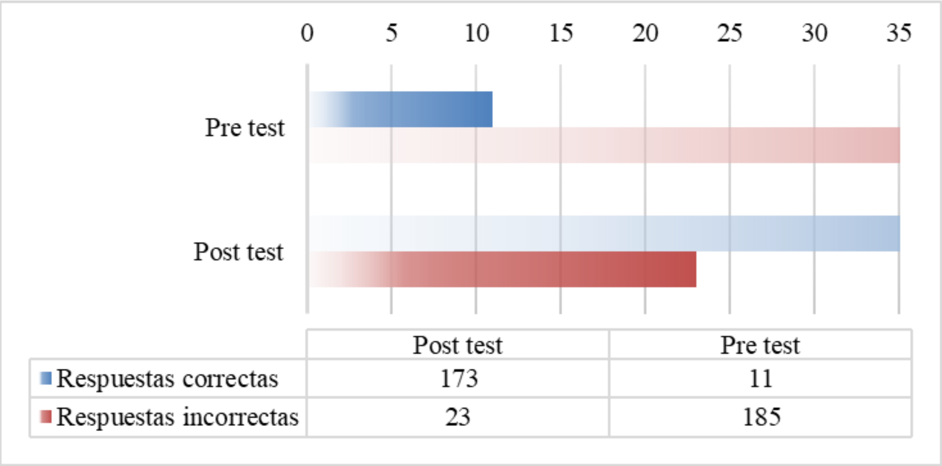
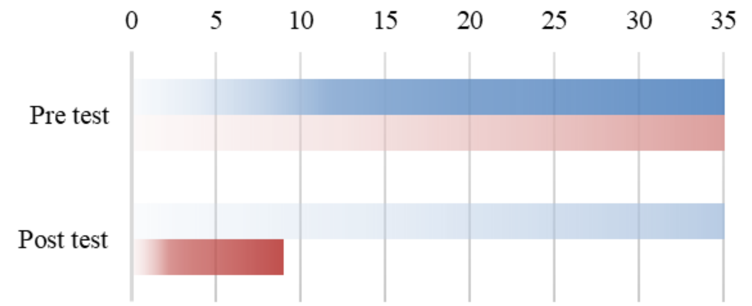


*Figure 23***.** Comparison pre and post test ninth question.

Note: Own elaboration.

The above evidences a greater appropriation of the statements mentioned and knowledge of both topics.

Regarding the tenth question, about the changes in the subject, an improvement can be evidenced in all students, since 95% answered correctly. This shows a marked difference compared to the results achieved in the pretest:

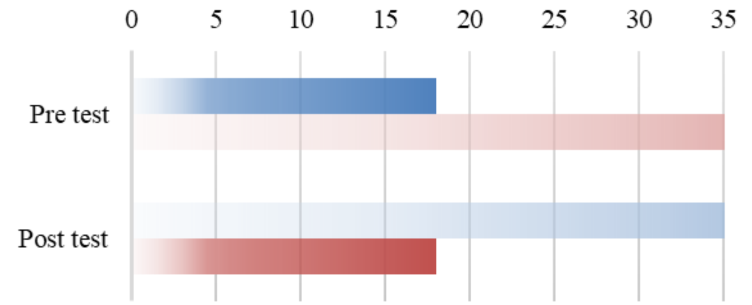


	Post test	Pre test
Respuestas correctas	187	47
Respuestas incorrectas	9	149

*Figure 24***.** Comparison pre and post test tenth question.

Note: Own elaboration.

Regarding the eleventh question on gaseous bodies, 91% of the students got the answer right and only 9% got it wrong. For this reason, there is greater clarity with respect to this type of knowledge; however, there are still students who persist with problems of clarity of concepts.



	Post test	Pre test
Respuestas correctas	178	18
Respuestas incorrectas	18	178

*Figure 25***.** Comparison pre and post test eleventh question.

Note: Own elaboration.

In the same direction, the last two open-ended questions showed a greater appropriation of the concepts and terms on the part of the students. Thus, in the first place, for the twelfth question, the students responded with respect to the differences between a living being and an inert being. Although the answers in the pre-test showed that the students were clear about the differences between living beings and inert beings, there was not a good command of key words, something that changed in the post-test results. Some results are shown in Figure 26:

> " - Los seres vivos nacemos crecemos nos reproducimos y nos morimos los seres inertes no tienen vida, no se pueden mover solos.
> - Los seres vivos realizan funciones vitales y los seres no vivos ayudan al ecosistema por ejemplo la luz del sol.
> - Los seres vivos nacen y crecen y los demás seres inertes no sienten nada."

*Figure 26***.** Fragments of answer to the twelfth post-test question.

Note: Own elaboration.

Secondly, for the last question, students were able to identify more than one state of matter, based on the image and the statement presented. In this sense, it is also evident that there is a greater understanding of the approach of the question and, likewise, a greater clarity regarding matter and its states. Some results are shown in Figure 27:

> " - Los seres vivos nacemos crecemos nos reproducimos y nos morimos los seres inertes no tienen vida, no se pueden mover solos.
> - Los seres vivos realizan funciones vitales y los seres no vivos ayudan al ecosistema por ejemplo la luz del sol.
> - Los seres vivos nacen y crecen y los demás seres inertes no sienten nada."

Figure 27. Fragments of answer to the twelfth post-test question.

Note: Own elaboration.

Secondly, for the last question, students were able to identify more than one state of matter, based on the image and the statement presented. In this sense, it is also evident that there is a greater understanding of the approach of the question and, likewise, a greater clarity regarding matter and its states. Some results are shown in Figure 28:

> "- Sólido, líquido y gaseoso.
> - Evaporación, condensación, fusión, solidificación.
> - Sólido, líquido y gaseoso y el estado de condensación."

*Figure 28***.** Answer fragments of the thirteenth post-test question.

Note: Own elaboration.

Finally, the results were evaluated based on the total score and its evaluation, in this case, the student body performed as follows (Figure 29):

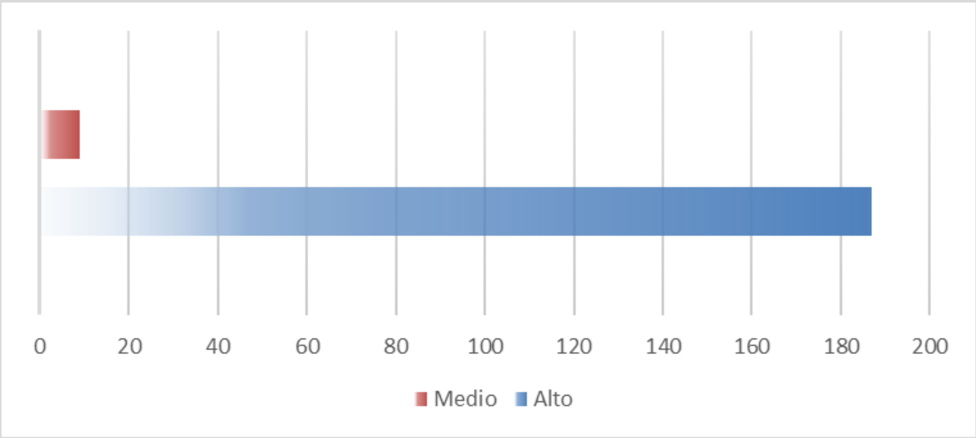


*Figure 29***.** Overall performance of students at post-test time.

Note: Own elaboration.

The data provided show that the student body had a high performance of 95% and only 5% obtained a medium performance. This fact was definitive to contrast the results of the post-test, thus establishing that of the 13 points evaluated in the post-test, most reached the maximum score and only a few people persisted in an average performance, although better than in the pretest. This shows the usefulness of experimentation for the achievement of significant learning in students.

Discussion and conclusions

In the first place, the diagnostic analysis through the pretest allowed us to identify a series of difficulties in the students with respect to the topics proposed in Natural Sciences for their specific cycle, mainly those related to the formation of tissues and organs, the processes of plants and the states of matter. This was not only evident in the low number of correct answers to the closed-answer questions, but also in the open answers provided by the students. There it was evident that they did not know the terms used, for example, the term photosynthesis, as well as the appropriate vocabulary to express their knowledge, for example, saying that water is heating instead of referring to the evaporation process. On the other hand, problems related to the lack of reading comprehension of the questions were also detected, since there were answers that did not correspond to what was asked of the students. These same needs have been identified by other authors such as Quiroz and Zambrano (2021), who report knowledge gaps in elementary school students in the subject of Natural Sciences.

Secondly, the construction of the laboratory guides was done in such a way that they were easy to understand for the students, with short and concrete activities. According to Torres and Guerrero (2018), part of the success of incorporating experimentation in the classroom corresponds to the proposal of dynamic learning through the design of simple experiments that do not involve greater complexity.

Regarding the observation guides, they reported four observations: first, that students are curious, interested and motivated to visit the laboratory spaces, interact with its tools and execute experimental tasks; second, that many times their interest leads them to adopt an impatient attitude, due to the limitation of the laboratory equipment and the large number of students; third, it was established that the laboratory visits have difficulties with respect to the limited equipment, which limits the presence of a large number of students and the presence of a single teacher in charge of the whole group; and fourth, the teacher stated that in the first sessions of the laboratory visits, she spent more time in keeping the students in order than in explaining in depth the topics covered.

Additionally, the post-test application moment revealed a positive aspect of the application of the proposed practical guides, since the students showed a significantly higher performance than the pre-test moment in all the questions of the applied instrument. In this sense, not only was there a higher number of correct answers, but also through the open response questions, a greater mastery of the terms mentioned, a more elaborated vocabulary, which allowed most of the students to give complete and correct answers to what was asked of them, could be evidenced. This also meant deeper reading and reflection processes, in which the student solved the questions according to what was specifically asked, in that sense, all students had a significant improvement, which is consistent with the results of research such as that of Meneses, et al.(2016) and that of Hernández and Villavicencio (2017).

Taking into account the characteristics of the population addressed, it is necessary to question the importance and relevance of the provision of laboratory equipment as a tool for the development of content in natural sciences, it is evident that by having these instruments, the learning processes will be much more significant, because through experimentation is that students can demonstrate the theoretical and conceptual processes that the teacher raises.

However, it is necessary to state that the educational gaps mark a predominance in the Colombian educational system, for this reason, it is quite complex that all students have access to laboratories that allow them a better experimentation of what they have learned in class. However, Jaramillo (2019), states that the teaching-learning practices related to Natural Sciences do not only depend on the elements that a laboratory can provide, therefore, the author calls for the creative actions of teachers, incorporating above all the elements that the context of the students allows them to handle for the development of learning.

In short, the intervention of the proposal made is considered as positive, with which it can be affirmed that experimentation is a valid educational strategy to reinforce meaningful learning in students, in contents of the area of Natural Sciences. This reaffirms what Pósito (2012) mentions regarding the fact that the study of science through experimentation is important to the extent that knowledge is built from reasoning, observation, critical and reflective analysis. Taking this into account, the continuity proposal emphasizes a curricular plan that advocates experimentation as the basis for teaching and didactic guides with which students participate in the generation of their own knowledge.

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