STRATEGY FOR THE STRENGTHENING OF SCIENTIFIC COMPETENCIES IN THE TEACHING OF CHEMISTRY

JAYSON BERNATE[1], INGRID FONSECA[2], ANGELA LOPEZ[3], ORLANDO SIERRA[4]
Corporacion Universitaria Minuto Dios UNIMINUTO[1]
https://orcid.org/0000-0001-5119-8916[1]
jbernate1@uniminuto.edu.co[1]
Universidad Pedagogica Nacional UPN-Corporacion Universitaria Minuto Dios UNIMINUTO [2]
https://orcid.org/0000-0002-3042-140X[2]
ingrid.fonseca@uniminuto.edu[2]
Corporacion Universitaria Minuto Dios UNIMINUTO[3]
https://orcid.org/0000-0002-8878-2187[3]
angela.lopez-o@uniminuto.edu.co[3]
Corporación Universitaria del Caribe CECAR[4]
https://orcid.org/0000-0003-3938-3670[4]
orlandorsd@gmail.com[4]

Abstract - *Scientific competencies are related to inquiry, argumentation and explanation processes. Its strengthening allows the understanding of nature and the environment. The objective of the study is to implement an educational strategy for the strengthening of scientific competencies in the teaching of chemistry. The methodology is mixed with the performance of laboratory activities. The sample is made up of 33 students of eleventh grade of an educational Institution located in a rural area of Colombia, who don't have technological resources (cellphone, computer, internet, among others). The data collection comes from a questionnaire of natural sciences (chemistry) that served as pre-test and post-test, a script of open questions and the activities developed in class and experiments. It is concluded that by implementing the didactic sequence it was possible to generate changes in the teaching of science and strengthen scientific thinking through experimentation in the classroom. It is recommended a cross-cutting approach of scientific thinking in subjects such as physics, biology and chemistry.*

Keywords: *Scientific competencies, natural sciences, teaching of chemistry, high-school education, teaching- learning.*

INTRODUCTION

Competencies are skills to carry out activities based on previously acquired knowledge (Fuentes et al., 2019; Quintanilla et al., 2005). They're related to the abilities of understanding, representing, interpreting and identifying contexts that lead to the transformation of reality (Ávila et al., 2020; Fuentes et al., 2019; Ruiz & Espinosa, 2020).

In regards to scientific competencies, they correspond to the study of phenomena based on the search and selection of information to generate argumentations and conclusions from Science (Sagástegui-Bazán, 2021). Therefore, it is necessary to carry out inquiry processes to provide answers and generate knowledge through research (Aditomo & Klieme, 2020; Hernández & Salamanca, 2017; Pedrinaci et al., 2012; Pérez & Meneses, 2020; Sanmartí & Márquez, 2017).

In this sense, a scientific literacy is proposed in order that the students are able to develop permanent learning among their lives (Alcaraz-Domínguez & Barajas, 2021; Juniar et al., 2020; Franco et al., 2014), strengthen abilities, knowledge, practices, actions and skills (Ávila et al., 2020; Gavilán et al., 2013; Serrano et al., 2015) and protect nature (Sagástegui-Bazán, 2021). On the other hand, being consistent with the Ministry of National Education of Colombia (MEN), the objective of formation through scientific competencies is to provide tools that contribute to the transformation of natural phenomena within the social context (Ávila et al., 2020; MEN, 2004).

However, in some educational institutions in Colombia, a traditional methodology of limiting the teaching of sciences through the orientation with a school textbook or teacher's speech prevails (Ruiz &

Espinosa, 2020). Scientific skills shouldn't be based on the accumulation of knowledge. On the contrary, they should tend towards applicability in daily life and context-based learning. It must be taken into account the relationship between skills, nature of the study of phenomena and the construction of significant learning (Blanchar, 2020; Fuentes et al., 2019; Hernández & Salamanca, 2017).

Competencies in natural sciences are related to curiosity when observing phenomena and identifying their characteristics. It seeks to carry out comparisons and describe significant aspects, reach consensus and build tools for decisions-making based on tangible evidence (Furman & Podestá, 2009; Quintanilla et al., 2005).

The teaching of natural sciences promotes the use of multiple methods to collect information, analyze, explore and observe facts or natural phenomena (Ávila et al., 2020; ICFES, 2015). In this sense, the laws that govern them are studied through a reflexive and conscious interaction (Ruiz & Espinosa, 2020). As a result or consequence of this, the student should be taught to resolve problems related to their environment, and at the same time understand that each individual can learn science in a different way (Fuentes et al., 2019; Quintanilla et al., 2005).

Similarly, the way of teaching science must be by generating understanding processes where reality can be represented. It seeks to integrate researching, educational and scientific processes with the interests of the student (Hernández & Salamanca, 2017; Martínez & González, 2014). In this regard, in the curricular guidelines of Natural Sciences of the Ministry of National Education of Colombia, pedagogical and didactical practices that are related to the formation based on scientific competencies are presented (Ávila et al., 2020; Caamaño, 2018; Cárdenas & Martínez, 2017; Izquierdo-Aymerich, 2017; Moreno-Crespo & Moreno-Fernández, 2015).

On this subject, Greca et al., (2021); Pérez & Meneses, (2020) and Torres-Porras & Alcántara-Manzanares (2022) propose that in Spain the basic curriculum, focused on elementary school education in the natural sciences area must provide the students with fundamentals for scientific formation. It contributes to the strengthening of competencies that allow it to evolve in transforming scientific and technological contexts (Daniyarova, et al., 2022; Diez-Ojeda et al., 2021; Osokoya & Nwazota, 2018). At the same time, external tests such as "Pruebas Saber" and "Pruebas PISA" (OCDE 2015) make evident the need to strengthen the competencies from elementary school (Rozo, 2017).

The importance of this study lies in the scarce research production about the teaching of sciences at an educational level (Obregoso et al., 2010). It is necessary to have spaces for reflexive teaching practices with a didactic mediation of the teaching, which shows the rights and wrongs during the process (Aydin-Gunbatar & Akin, 2022). This will give rise to favoring autonomous learning through effective pedagogical strategies that promote the interest in natural sciences (Diez-Ojeda et al., 2021).

Based on the stated, the objective of this research was to implement an educational strategy to strengthen scientific competencies in high-school students in the teaching of chemistry. In this sense, laboratory activities were carried out based on the explanation of phenomena, the comprehensive usage of scientific knowledge and inquiry.

Teaching and learning processes in the area of natural sciences are based on the resolution of contextual problems and scientific content. In addition, in the 21st century, the school must transform learning methodologies as well as the materials that are being used (Ávila et al., 2020; Ravanal & Quintanilla, 2012). This is with the purpose of responding to the needs of teaching and learning in order to understand and be participants in their social environment (Hernández & Salamanca, 2017).

There must be changes, taking into account that students have innate curiosity and an exploratory idiosyncrasy, and that they're able to ask constantly. In this regard, cognitive development is directly related to learning, and when experienced, previous ideas are directly connected with conceptual changes (Martín & Martínez-Aznar, 2022; Fuentes et al., 2019).

It is necessary to carry out inquiry processes as one can't learn through concepts, but from daily life situations (Diez-Ojeda et al., 2021; Furman & Podestá, 2009). Moreover, carry out strategically sequenced activities, taking into account the learner from their previous knowledge, promoting social and cultural integration (Alcaraz-Domínguez & Barajas, 2021; Pérez & Meneses, 2020).

This transformation highlights the importance of interaction between people and their environment. This is how, in the case of the classroom, students respond to stimuli generated by a mediating agent (the teacher) (Martín & Martínez-Aznar (2022); Tébar, 2009).

Therefore, a culture of exchange must be fostered in the classroom, so that classmates interact with each other and base their ideas with evidence. Additionally, Franco et al., (2014) emphasize on the importance of implementing innovative reforms with appropriate didactical material that can be used in class. It is necessary to choose experiences in order to know when to use stimuli (Ruiz y Espinosa, 2020).

In the last 20 years, interest in the study of teaching methodologies, pedagogical and didactical practices has increased (Aydin-Gunbatar & Akin, 2022; Ávila et al., 2020). In regards to this, significant changes in teachers' strategies are presented, as these are guidelines for learning processes. But it must not be set aside from the students' role to obtain an active participation (Fuentes et al., 2019; Quintanilla et al., 2005).

The development of scientific competencies is related to the abilities of understanding, identification, interpretation and representation of contexts. In this way, it is intended to transform an individual's reality taking into account methodological and social aspects (Pérez & Meneses, 2020; Ruiz & Espinosa, 2020). Processes that are based in the use of scientific language, strengthening of experimental skills and group work must be included.

It is necessary to implement learning activities, however, it is complex and can be demonstrated through actions (Sanmartí & Márquez, 2017). It is important to use tools in order to develop and also to incorporate and maintain learning during life (Franco et al., 2014).

The concept of science is classified as an action with human purposes and therefore, it is needed for coherent knowledge of conceptual evolutions through scientific thinking (Fuentes et al., 2019; Quintanilla et al., 2005). In chemical sciences, scientific competencies serve to build concepts and to relate phenomena, thanks to their explanations (Quintanilla, 2014).

Inquiry and use of scientific knowledge through articulation between practice and theory must be promoted. Also generate a scenery where the student embraces knowledge in a simple way and can have significant learnings (Ávila et al.,2020; Rodríguez & Blanco, 2021; Torrecilla et al., 2016). It is fundamental to implement strategies to teach how to observe remarkable aspects that a phenomena can have. As well as encourage observation with similar and/or different elements and to portray them in schemes or graphics. Through experiences, the surrounding world can be understood and the liking of exploring it and interact with it can be promoted (Franco et al., 2014; Fuentes et al., 2019; Pedrinaci et al., 2012; Torres-Porras & Alcántara-Manzanares 2022).

It is necessary to approach scientific competencies from the teaching of chemical science with specific content. This can not be abstract and also scientific inquiries must not be promoted if there is no theoretical framework delimited (Carrascosa - Alís et al., 2020). In regards to teaching of chemical sciences, teachers must shape students that are able to understand concepts (Fensham, 2007; Quintanilla, 2014; Ávila et al., 2020). The proposal is to teach how to ask questions based on learned topics (Aditomo & Klieme, 2020; Franco et al., 2014; Torres-Porras & Alcántara-Manzanares, 2022).

It can be said that teaching scientific competencies is a relevant topic but not much organized, this is because reaching the proposed recommendations in a curriculum is not a simple task, resulting then with a document full of ideas that aren't put into practice (Furman & Podestá, 2009).

1. Methodology

The study is framed in a mixed approach with the performance of laboratory tasks with a duration of three months (two weekly sessions). It is deepened in the understanding of the problems through qualitative and quantitative data in order to transform the situation that affects the involved population (Todd & Lobeck, 2004). Through a constant reflection, changes in their contexts are rebuilt and proposed. In this way, the practice can be improved because problems are being identified in the teaching-learning process. Likewise, possible solutions are proposed and strategies can be validated if they're working (Botella & Ramos, 2019). The current inquiry was done in the second semester of 2021, between August and October.

1.1 Participants

The population was made of 33 high-school students (15-16 years old) from eleventh grade of an Educative Institution in Cundinamarca's department (state) in Colombia, that were enrolled in chemistry classes. The sample was intentional and not random, given that it was important to rely on the information of all students. It included a total of 20 girls (60.6%) and 13 boys (39.4%), 15 of them living in rural areas and 18 in the urban area of Villagómez town in Cundinamarca. All kids have similar socio-cultural characteristics: level 1 socioeconomic status (from 6 statuses available in Colombia, being level 1 the lowest), reading and writing mid-level. They don't have available technological resources (i.e. cellphone, smartphone, computer, internet access, among others) and they have a limited access to information. The teacher of this school subject has a major in Food Chemistry, has been working in the school for 4 years and is the author of this research.

1.2. Data collection instruments

The first instrument was a Natural Sciences (Chemistry) Questionnaire that had 10 multiple choice questions that were also available on the booklet of the "Saber 11°" Natural Sciences Test from the 2018 ICFES test. These were used on previous exams and contain the 3 topics of natural sciences (Physics, Chemistry and Biology). For the current study, 10 questions from the Chemistry topic were exclusively chosen, taken into account that this is the target topic. Evenmore, they were allocated so at least one of them could be based in each one of the three scientific competencies to strengthen. (Attachment 1).

This questionnaire served as a pre-test and a post-test. In the pre-test, students' previous knowledge regarding Chemistry subject and the application of processes of scientific thinking through inquiry were determined. A week after the pedagogical intervention, a post-test activity was carried out (Attachment 2), identical to the pre-test, with the aim of evaluating acquired knowledge in the three scientific competencies.

As the second instrument, a script of 10 open questions was implemented with the purpose of knowing their perception regarding the education they have received. The responses were recorded and transcribed.

Given the nature of the study, the questions before the implementation were analyzed and categorized by carrying out an analysis of components. Consistency was checked by a group of experts. The process was carried out by one of the authors for 10 days until the definitive instrument was obtained.

Based on this information, a didactic sequence with organized activities was carried out so that the students can obtain significant learning through experiments. In this way, the use of scientific thinking and contact with the environment are strengthened.

A series of workshops were developed based on theoretical references and the results of the pre-test to generate spaces for the development of significant learning. These were related to the inquiry and the appropriation of scientific knowledge through experimentation.

The Basic Standards of Competencies in Natural Sciences included in documents from the Ministry of National Education of Colombia were taken into account (MEN, 2002) (Table 1).

Table 1. Descriptions of the Scientific Thinking competencies described by the MEN (2002).

Competence	Description
Phenomena Explanation	Through patterns, observations and their own concepts, students are able to extract evidence from scientific research. This allows them to analyze variables to model natural phenomena.
Comprehensive use of scientific knowledge	In this category, through analysis of their own concepts, students are able to identify natural phenomena and its characteristics.
	Students understand that the construction of explanations about the natural world are made through scientific research. They

Inquiry	generate conclusions based on their own evidence, observe and relate patterns.

1.3. Description of didactical experience

Activities carried out in the academic intervention process were sequenced in six stages, each of them was done in two sessions of two hours each, so the total duration of the implemented educative sequence was of 48 hours (6 experiments during 12 weeks). Topics discussed and experiments are presented next:

(i). Class research. First part of the experiment session was based on inquiry of theoretical aspects. The students researched scalar quantities, properties of water (adhesion and capillary action), inorganic chemical reactions, combustion reactions and saponification reactions. Concepts were clarified through some master classes and other ones through the development of guiding questions. Likewise, the teacher generated discussion spaces in an active and direct manner. With constant interventions, she directed the sequence.

(ii). Conducting experiments. In the second part of the work session, experimental activities were conducted: lava lamps; in which the students remembered density topics by mixing water, oil effervescent substances and dyes. Subsequently, they conducted the “Water thread” and “Rainbow” experiments, where they observed some properties of the water (adhesion and capillary action) by using a fique string and colored napkins.

Next, sodium bicarbonate and acetic acid were poured in a plastic bottle covered with a balloon to witness an acid-base reaction (inorganic chemical reactions). Next experiment was a combustion reaction in order to identify organic compounds. Subsequently, a Netwonian fluids experiment was conducted in order to prove Newton’s Laws of Viscosity along with reviewing Fluid Mechanics topic. Lastly, soap was produced through the Hydrolysis of an Ester.

1.4. Development of the activities

Implementation of the sequence of activities in the classroom was carried out through two sessions during 6 weeks, with a duration of 2 hours each of them (Table 2).

Table 2. Experiments conducted during each class session.

# of class session	Included Experiments	Basic Standards of Competencies	Competencies	Basic Learning Rights (BLR)	Content

1	Lava Lamp. Exploration of previous knowledge. Initial conceptual associations. Conducting an experiment (mixing water, oil and a dye with an addition of an effervescent tablet that releases CO_2).	To identify chemical changes in the environment in everyday life. (MEN, 2004) To explain different models through chemical changes. (MEN, 2004).	Comprehensive use of scientific knowledge. Inquiry Phenomena Explanation.	"To understand that temperature (T) and pressure (P) affect some physico-chemical properties of substances (solubility, viscosity, density, boiling and melting points)" (MEN, 2016, p.21).	Scalar quantities (density)
2	Water thread and Rainbow. Conducting an experiment (using a fique string attached to the edge of two glass beakers. Then water was passed through the string without spilling a drop and colored napkins were used. These napkins were moistened to displace the dyes and create a rainbow pattern).	To explain the behavior of fluids at rest, as well as in motion. (MEN, 2004).	Phenomena Explanation.	"To understand the classification of materials from groups of substances (elements and compounds) and mixtures (homogeneous and heterogeneous)" (MEN, 2016, p.22).	Properties of the water (adhesion and capillary action).
3	Self inflating balloon. Conducting an experiment (pouring sodium bicarbonate and acetic acid in a plastic	To explain the relationship between atom structures and the atom bondings it forms. (MEN, 2004).	Phenomena explanation. Comprehensive use of scientific knowledge.	"To understand different mechanisms of chemical reactions (oxidation-reduction, decomposition, neutralization), that allow the	Inorganic Compound Reactions (Acid-Base Reaction)

	bottle covered with a balloon. This results in carbon dioxide being produced and it inflates the balloon.	To prove the effects of temperature and pressure in chemical changes (MEN, 2004).		formation of inorganic compounds" (MEN, 2016, p. 35).	
4	Spontaneous combustion. Conducting an experiment (Chemical reaction between potassium permanganate and glycerin to oxidize. Carbon is produced and it generates a combustion).	Use of the periodic table to determine physico-chemical properties of the elements. (MEN, 2004). Structure of the carbon and formation of organic molecules. (MEN, 2004).	Inquiry Phenomena explanation.	"To understand that different mechanisms of chemical reactions (oxidation-reduction, homolysis, heterolysis and policyclics) allow the formation of different types of organic compounds" (MEN, 2016, p. 35).	Chemical reactions of organic compounds (Combustion reaction)
5	Newtonians Fluids. Conducting an experiment (mixing water with cornstarch to observe its behavior by changing its temperature and pressure).	Characterization under equilibrium conditions of chemical changes. (MEN, 2004). Performing quantitative calculations within chemical changes. (MEN, 2004).	Inquiry Comprehensive use of scientific knowledge.	"To analyze quantitative relationships between solutes and solvents, as well as the agents that affect the formation of solutions" (MEN, 2016, p.31).	Fluid mechanics (Newton's Viscosity Law)
6	How to make soap Conducting an experiment (Mixing Sodium Hydroxide with coconut oil to	Control of the rate of chemical changes by identifying conditions. (MEN, 2004).	Comprehensive use of scientific knowledge. Inquiry	"To understand that in a chemical reaction, atoms of the molecules of the reactives are recombined to generate new products, and	Hydrolysis of an Ester (Saponificati on)

	produce soap and glycerin).	Relationship between functional groups and physico-chemical properties of substances (MEN, 2004).		said products are formed by intramolecular forces (Ionic and covalent bonds)" (MEN, 2016, p. 27).	

2.Results

In order to provide an answer to the research objective, it was taken into account what was stated by the Institute for the Evaluation of Education in Colombia in the reference framework for the Evaluation (ICFES, 2018). The competencies to evaluate in natural sciences were comprehensive use of scientific knowledge, phenomena explanation and inquiry. Subsequently, it was developed based on the processes related to the subject of Chemistry.

When analyzing the recording and transcript of the open questions activity, it was determined that the students do like the subject of chemistry. However, it was considered uninteresting because it involves memorization processes and it is difficult due to the topics covered. In this sense, they understand that some activities of daily life are related to chemical processes, but most of them do not perceive the applicability of the subject.

This is how Camilo considers that [Extracted from the transcript of the open questions activity] "in high-school, chemistry and physics teachers are bad-tempered and authoritarian, they don't explain, they only scold us, tell us to apply formulas and conduct few experiments". On the other hand, Tatiana expresses that chemistry classes [Extracted from the transcript of the open questions activity] "should be practical in order to discover things, learn to conduct simple experiments, go to the lab, receive explanations of topics with the aid of videos and pictures so that it is easier for understanding them".

To begin with the implementation of the educational strategy, the methodology to be implemented was introduced to the students. Most of them agreed that the classes should have 2 parts: a theoretical part, where the fundamentals of the phenomena to be studied are explained; and the second part should be practical and enjoyable, where students can interact with objects, substances and/or materials.

Figure 1. a. Explanation of the open-question questionnaire to the students

b. A student answering the pre-test in the initiation stage of the pedagogical intervention.

In regards to the implementation of the pre-test, success rate for each one of the 10 questions is represented on Figure 2. There it can be seen that in only two of the items raised, a level of success superior to 30% was obtained, one of them is focused in the scientific competence "phenomena explanation" and the other one in "use of scientific knowledge". The others obtained a low success rate, highlighting questions 2 and 5 with scores of 6.25% and 9.38%, respectively, which proved an unsatisfactory performance.

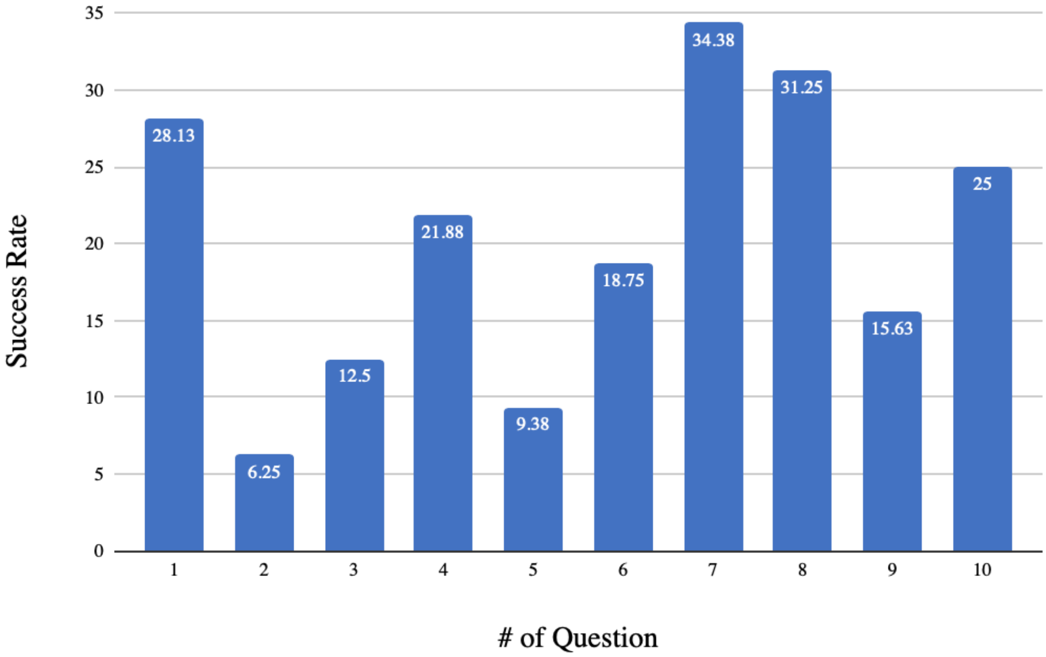

Figure 2. Students' success rate in each of the questions of the pre-test.

Afterwards, the activities were carried out within classroom practices and students' willingness regarding experimental classes was evidenced. Curiosity was the classroom protagonist because the laboratory implements that were stored were used for some practices. This situation was unusual for them given that they didn't have a chance to use them over the past years.

Theoretical references were implemented through knowledge acquisition by consultations that were carried out by the students and shared with their classmates through round table discussions, brainstorming, explanatory graphics, among others. Nevertheless, when they were asked to share their own ideas within each topic's context, they were limited to paraphrasing some ideas already shared. This evidenced that their previous knowledge regarding some topics were limited.

Figure 3. a. Theoretical explanation of the experiments to be conducted

b. Sharing consultations, previous knowledge and brainstorming

As the implementation of the proposed sequence progressed, when finishing each topic, a significant improvement was observed in each work group in terms of topic mastery and conceptualization. This recognition became evident as students reinforced concepts and identified key ideas by placing the topics covered within their social context. Similarly, it was proved that an experimental laboratory can be set up anywhere, in this case, within their own classroom.

Figure 4. a. Teacher's guidance during students' experimentation process.

b. Conducting the water thread experiment and proving theoretical concepts of capillary action.

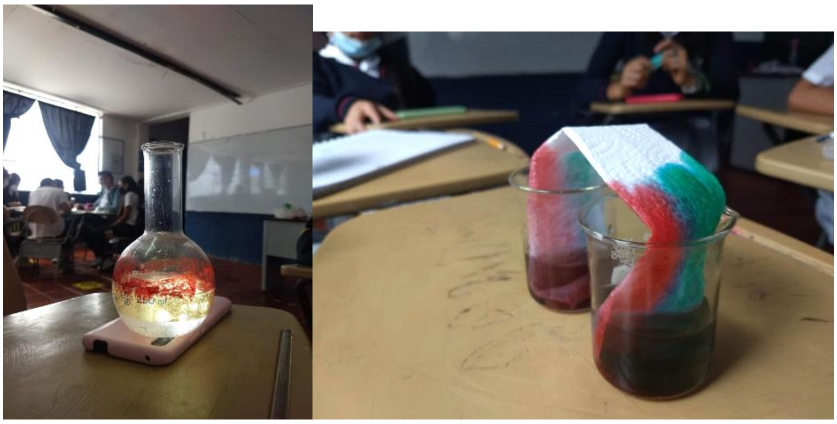

Figure 5. a. Conducting the lava lamp experiment. b. Conducting the rainbow experiment.

Figura 6. a. Teacher's guidance when conducting the Newtonian Fluids experiment.

b. Experimental confirmation of the properties of Newtonian Fluids by the students.

Lastly, the results of the post-test served to determine the level of development of the scientific competence after carrying out the pedagogical intervention. These can be observed in figure 7, which shows the success rate the students had in each question. It is evident that in the first question they obtained the highest score and most of them were above 20%. The only question where a low rate was evident was the third one, with a success rate of 12.5%

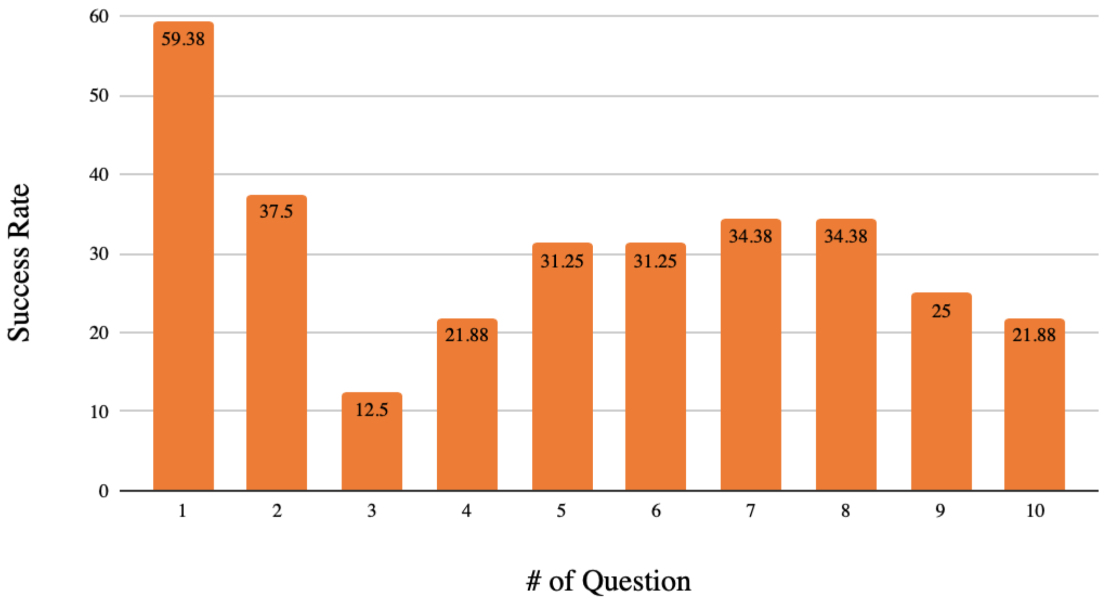

Figure 7. Students' success rate in each question of the post-test.

It can be observed that when comparing the results of the pre-test and the post-test (Figure 8), in more than half of the questions, there was an increase in the success rate. Three of them remained the same in questions 3, 4 and 7, superior to the 10%, while only in question #10 a decrease in the success rate was observed. This proved an increment in the development of scientific competencies (Figure 8).

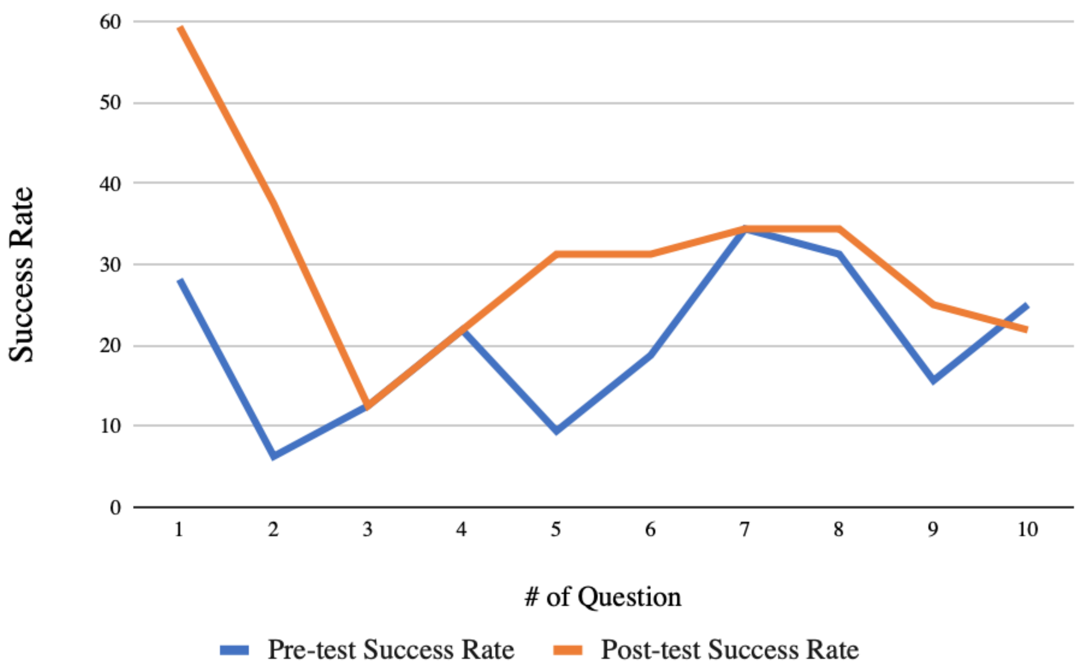

Figure 8. Students' success rate in each of the questions, comparison between Pre-test and Post-test results.

Questions will be organized according to the competencies that can be observed in table 3. There were five questions about phenomena explanation, four about comprehensive use of scientific knowledge and one about inquiry. It should be highlighted that the level of difficulty of each question is given by the "ICFES" in Colombia, and this information can be observed at the end of ICFES booklet, in the section about information of each question.

Table 3. Comparison of Pre-test and Post-test results. Behavior of variables.

# of Question	Pre-test success rate	Post-test success rate	Behavior of the variable	Competence	Level of development
1	28.13	59.38	Increased	Comprehensive use of scientific knowledge	3
2	6.25	37.5	Increased	Phenomena explanation	1
3	12.5	12.5	Maintained	Comprehensive use of scientific knowledge	1
4	21.88	21.88	Maintained	Phenomena explanation	1
5	9.38	31.25	Increased	Inquiry	1
6	18.75	31.25	Increased	Phenomena explanation	1
7	34.38	34.38	Maintained	Phenomena explanation	1
8	31.25	34.38	Increased	Comprehensive use of scientific knowledge	1
9	15.63	25	Increased	Comprehensive use of scientific knowledge	1
10	25	21.88	Decreased	Phenomena explanation	1

5.Discussion

The current research provides evidence that in natural sciences there must be a relationship between academic context and practical classes (Ávila et al., 2020; Caamaño, 2018). In this sense, problems based on activities that surround the students, such as making soap, lava lamps, self inflating balloons, water threads, among others, were solved. In this way, spaces were generated so that they have understanding processes through the teaching of science (Fuentes et al., 2019; Quintanilla et al., 2005).

By teaching natural sciences in this way, it is possible to encourage research (Obregoso et al., 2010) and by implementing teacher practices that benefit them (Pedrinaci et al., 2011; Ruiz & Espinosa, 2020). In this sense, it should be taken into account the school grade, level of formation and adequate teaching methodologies. Also, to offer innovative content to promote scientific competencies (Fensham, 2007). When implementing this didactic sequence, the teacher's role as a mediator with an active role to guide them through playful activities was essential (Hernández & Salamanca, 2017).

In this order of ideas, it is important to highlight that the said competencies are not acquired spontaneously, but must be taught. For this, the assigned teacher played a major role in the guidance of each of the experimental activities, encouraging reflection for its understanding and generating the required stimuli to promote an adequate interest (Diez-Ojeda et al., 2021; Furman & Podestá, 2009).

In regards to this, teachers' point of view must be taken into account so that they can argue based on sustainable evidence, as well as reflect, analyze, synthesize and promote spaces for self-criticism (Romaña, 2016).

Is this how it is proposed to implement these innovative experiences by finding explanations of how the natural world works through the exploration (Fuentes et al., 2019; Furman & Podestá, 2009; Torres-Porras & Alcántara-Manzanares, 2022). But for this, there must be joint work to implement methodologies that can favor the development of basic competencies (Fensham, 2007; Franco et al., 2014).

Another aspect that can be highlighted from the application of the didactic sequence worked on in this research is the acceptance it had from the students, the laboratory practices and the materials used in each topic. What some authors pointed out regarding understanding scientific thinking as the ability to respond to the proposed requirements in any scientific activity within the educational context was confirmed (Ávila et al., 2020). Since, through the search of science related data, broad knowledge can be acquired (Quintanilla, 2014).

Within the planning of the activities, the abilities observed in the pre-test results were taken into account, following a structure that prioritizes didactic topics based on guiding questions (Fuentes et al., 2019). It was evidenced that the experiments carried out were integrated into a context that allowed them to create concepts. This was done through the use of thinking tools that could be supported through the data they collected and hypotheses they raised at the end of each experience.

The main approach is to strengthen researching abilities within the school context, especially the methodological dimension (Pérez & Meneses, 2020). For this, within the sessions of feedback and socialization of the results of the activities, the identification of problems was evidenced. Similarly, observation collection and organization of relevant data, analysis of results, development of conclusions and the communication of the same. In this sense, teamwork and proper use of the materials with which the students work, become important (Juniar et al., 2020; Martínez y González, 2014, Martín & Martínez-Aznar 2022).

Regarding the development of elements of scientific thinking, it was determined that through the structuring of contextual and conceptual learning through the implementation of the didactic sequence, the acquisition of the competencies was favored. The aspects that could contribute were the interaction with chemical elements and materials, joint work, dialogue and argumentation. Similarly, by applying this methodological work of significant experiences, the participation of the students was increased.

The population with which the study was done can be highlighted as an innovative component of the same. This is because they are students who live in the rural area of the town where the Educational Institution is located. They don't have the necessary resources in their daily life, school supplies nor adequate nutrition. They can be placed in the lowest socio-economic level, so school dropout, poor study habits and little interest in the school subjects taught are the common denominator. For this reason, the positive results shown by the current research stand out in a country like Colombia, in which changes that lead to social and educational transformations are needed (Pozo, 2016).

Regarding the evaluation instruments that were used, it can be highlighted that they were consistent with the experimental activities. It was possible to carry out a progressive assessment of the favorable results in terms of scientific thinking in order to improve its development in practices that include scientific inquiry (Aditomo & Klieme, 2020; Williams & Dries, 2022). Moreover, an adequate environment was also created to work on the said competencies. The relevance they had in daily life was evidenced, the students were encouraged and there was a didactical treatment within the classroom (Franco et al., 2014; Greca et al., 2017). This shows that implementing methodologies that promote research through experimentation in the classroom, enables the acquisition and strengthening of scientific competencies (Torres-Porras & Alcántara-Manzanares, 2022). This can be achieved through processes in which the students can build their knowledge of the natural world in a meaningful way.

Despite that, the proposal had certain limitations such as time and availability of materials, this because there were only 12 weeks for the project. Due to the SARS-CoV-2 pandemic, the project began to be implemented back in August 2021, when the educational community started to go back to physical classes within the educational institution. The authors consider that in order to obtain better results, there should be a context of teaching, learning and daily experience so that it is continuously strengthened. Another limitation was the lack of chemical reagents and materials to carry out experimental practices, which is why we had to use our own resources to complete them. Despite this, it was possible to count on the responsibility, commitment and disposition from the students during the work carried out.

This research generates a contribution to the field of research on scientific competencies, their development and strengthening in high-school education. This is how the importance of constantly developing laboratory tasks with active participation is highlighted. In this sense, it is necessary to train teachers to promote such participation. As well as having a cross-cutting approach in the curriculum of other scientific school subjects such as physics and biology, thus implementing experimental practices (Daniyarova et al., 2022; Martín & Martínez-Aznar (2022); Juniar et al., 2020; Corredor & Saker, 2017).

CONCLUSION

Teachers are invited to exchange traditional practices for inspiring methodologies and embrace a new culture of science learning. The teaching process must be addressed by using intentional strategies through specific activities based on school content. It is essential to understand chemical phenomena by identifying, explaining and working jointly with the students. The authors of this study consider that the results presented can serve as a useful reference for academics who wish to promote scientific competencies in the school subject of chemistry and natural sciences in high-school.

REFERENCES

[1] Aditomo, A., & Klieme, E. (2020). Forms of inquiry-based science instruction and their relations with learning outcomes: Evidence from high and low-performing education systems. International Journal of Science Education, 42(4), 504-525. https://doi.org/10.1080/09500693.2020.1716093

[2] Alcaraz-Dominguez, S., & Barajas, M. (2021). Conceiving socioscientific issues in STEM lessons from science education research and practice. Education Sciences, 11(5), 238. https://doi.org/10.3390/educsci11050238

[3] Ávila, O. D., Lorduy, D. J., Aycardi, M. P., y Flórez, E. P. (2020). Concepciones de docentes de química sobre formación por competencias científicas en educación secundaria. Revista Espacios, 41(46), 244-260.

[4] Aydin-Gunbatar, S., & Akin, F. N. (2022). Pre-service chemistry teachers' use of pedagogical transformation competence to develop topic-specific pedagogical content knowledge for planning to teach acid-base equilibrium. Chemistry Education Research and Practice, 23(1), 137-158. https://doi.org/10.1039/D1RP00106J

[5] Blanchar, F. (2020). Características de la práctica pedagógica en el área de Química. Revista Científica, 1(37), 30-57. https://doi.org/10.14483/23448350.14855

[6] Botella Nicolás, A. M., y Ramos Ramos, P. (2019). Investigación-acción y aprendizaje basado en proyectos. Una revisión bibliográfica. Perfiles educativos, 41(163), 127-141.

[7] Caamaño, A. (2018). Enseñar química en contexto: un recorrido por los proyectos de química en contexto desde la década de los 80 hasta la actualidad. Educación Química, 29(1), 21.https://doi.org/10.22201/fq.18708404e.2018.1.63686

[8] Carrascosa-Alís, J., Martínez, S., y Alonso, M. (2020). Competencia Científica y Resolución de Problemas de Física. Revista Científica, 38(2), 201-215. https://doi.org/10.14483/23448350.16211

[9] Corredor, O. M., y Saker, J. (2017). Perspectiva de la Formación Científica de Docentes en Instituciones de Educación Básica y Media - Barranquilla. Educación y Humanismo, 20(34), 156-172. https://doi.org/10.17081/eduhum.20.34.2862

[10] Daniyarova, A., Suad, A., Vecherinina, E., Seluch, M., & Ananishnev, V. (2022). Games for Science Education: is this technique effective for developing students' creativity and scientific competence?. World Journal on Educational Technology: Current Issues, 14(1), 28-41. https://doi.org/10.18844/wjet.v14i1.6629

[11] Diez-Ojeda, M., Queiruga-Dios, M. Á., Velasco-Pérez, N., López-Iñesta, E., & Vázquez-Dorrío, J. B. (2021). Inquiry through Industrial Chemistry in Compulsory Secondary Education for the Achievement of the Development of the 21st Century Skills. Education Sciences, 11(9), 475.https://doi.org/10.3390/educsci11090475

[12] Fensham, P. J. (2007). Interest in science: Lessons and non-lessons from TIMSS and PISA. Contributions from science education research, 3-10. Springer, Dordrecht.

[13] Author., (2018). Learning strategies in Colombian university students. Proceedings of the 10th International Conference on Education Technology and Computers, 231-234.

[14] Franco, A. J., Blanco-López, Á., y España-Ramos, E. (2014). El desarrollo de la competencia científica en una unidad didáctica sobre la salud bucodental. Diseño y análisis de tareas. Enseñanza de Las Ciencias.

Revista de Investigación y Experiencias Didácticas, 32(3), 649-667. https://doi.org/10.5565/rev/ensciencias.1346

[15] *Fuentes, D. M., Puentes, A., y Flórez, G. A. (2019). Estado Actual de las Competencias Científico Naturales desde el Aprendizaje por Indagación. Educación Y Ciencia, 23, 569–587.*https://doi.org/10.19053/0120-7105.eyc.2019.23.e10272

[16] *Gavilán, I., Cano, S., y Aburto, S. (2013). Diseño de herramientas didácticas basado en competencias para la enseñanza de la química ambiental. Educación Química, 24(3), 298–308.* https://doi.org/10.1016/s0187-893x(13)72479-0</div>

[17] *Greca, I. M., Meneses Villagrá, J. A., y Diez Ojeda, M. (2017). La formación en ciencias de los estudiantes del grado en maestro de Educación Primaria. Revista Electrónica de Enseñanza de las Ciencias, 16(2).*

[18] *Greca, I. M., Ortiz-Revilla, J., y Arriassecq, I. (2021). Diseño y evaluación de una secuencia de enseñanza-aprendizaje STEAM para Educación Primaria. Revista Eureka sobre Enseñanza y Divulgación de las Ciencias, 18(1), 180201-180219.*

[19] *Hernández, C. A., y Salamanca, X. (2017). Fortalecimiento de competencias científicas: La investigación como estrategia pedagógica. Horizontes Pedagógicos, 19(2), 91–100.*https://doi.org/10.33881/0123-8264.hop.19205

[20] *ICFES (2015) Matriz de Referencia Ciencias naturales 11° ¿Qué aprendizajes evalúan las Pruebas Saber? Bogotá, Colombia.*

[21] *ICFES (2018) Cuadernillo de preguntas Saber 11°. Prueba de Ciencias Naturales. Instituto para la Evaluación de la Educación. Bogotá, Colombia.*

[22] *Izquierdo-Aymerich, M. (2017). Atando cabos entre contexto, competencias y modelización ¿Es posible enseñar ciencias a todas las personas? Modelling in Science Education and Learning, 10(1), 309.* https://doi.org/10.4995/msel.2017.6637

[23] *Juniar, A., Silalahi, A., & Suyanti, R. (2020). The Effect of Guided Inquiry Model on Improving Student's Learning Outcomes and Science Process Skill in Qualitative Analytical Chemistry Practikum. Universal Journal of Educational Research, 8(11), 5457-5462.* https://10.13189/ujer.2020.081149

[24] *Martín, A. I. B., & Martínez-Aznar, M. M. (2022). Indagar sobre las reacciones químicas y desarrollo de la competencia científica. Enseñanza de las Ciencias. Revista de investigación y experiencias didácticas, 40(2), 5-23.* https://doi.org/10.5565/rev/ensciencias.3409

[25] *Martínez, C., y Gónzalez, C. (2014). Concepciones del profesorado universitario acerca de la ciencia y su aprendizaje y cómo abordan la promoción de competencias científicas en la formación de futuros profesores de Biología. Enseñanza de Las Ciencias, 32(1), 51-81.*https://doi.org/10.5565/rev/ensciencias.852

[26] *Ministerio de Educación Nacional (MEN) (2002). Estándares Curriculares para Ciencias Naturales y Educación Ambiental. Bogotá: Ministerio de Educación Nacional.*

[27] *Ministerio de Educación Nacional (MEN) (2004) Estándares básicos de competencias en ciencias sociales y ciencias naturales. Formar en Ciencias: el desafío, lo que necesitamos saber y saber hacer. Revolución educativa Colombia Aprende. Editorial Espantapájaros Taller. Colombia.*

[28] *Ministerio de Educación Nacional (MEN) (2016). Derechos básicos de aprendizaje en ciencias naturales. Dirección de calidad para la educación preescolar, básica y media. Vol. 1. Panamericana, formas e impresos S.A. Bogotá. D.C. Colombia.*

[29] *Moreno-Crespo, P., y Moreno-Fernández, O. (2015). Problemas socioambientales: Concepciones del profesorado en formación inicial. Andamios, 12(29), 73–96.* https://doi.org/10.29092/uacm.v12i29.20

[30] *Obregoso, A., Vallejo, C., y Valbuena, E. (2010). Ciencias naturales en educación primaria: algunas tendencias, retos y perspectivas. EDUCyT, 2(2).*

[31] *OCDE (2015). PISA 2015, Resultados Clave. Recuperado de:* https://www.oecd.org/pisa/pisa-2015-results-in-focus-ESP.pdf

[32] *Osokoya, M. M., y Nwazota, C. C. (2018). Problem-Based and School-Type as Contributory Factors to the Senior Secondary School Students' Practical Skills in Chemistry. Journal of the International Society for Teacher Education, 22(1), 7-18.*

[33] *Pedrinaci, E., Caamaño, A., Cañal, P., y de Pro, A. (2012). 11 ideas clave: el desarrollo de la competencia científica (19). Graó.*

[34] *Pérez, S., y Meneses Villagrá, J. A. (2020). La competencia científica en las actividades de aprendizaje incluidas en los libros de texto de Ciencias de la Naturaleza. Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias, 17(2), 617 - 627.*https://doi.org/10.25267/rev_eureka_ensen_divulg_cienc.2020.v17.i2.2101

[35] *Pozo Serrano, F. J. D. (2016). Pedagogía social escolar en Colombia: el modelo de la Universidad del Norte en formación directiva y docente para la ciudadanía y la paz. Revista Iberoamericana de educación.*

[36] *Quintanilla, M. (2014). Las Competencias de Pensamiento Científico desde las "emociones, sonidos y voces" del aula. Santiago: Editorial Bellaterra Ltda.*

[37] *Quintanilla, M., Izquierdo i Aymerich, M., y Adúriz-Bravo, A. (2005). Avances en la construcción de marcos teóricos para incorporar la historia de la ciencia en la formación inicial del profesorado de Ciencias Naturales. Enseñanza de las Ciencias.1-4*

[38] *Ravanal, E., y Quintanilla, M. (2012). Creencias del Profesorado de Educación Básica en formación sobre la enseñanza de la ciencia escolar: Análisis desde un debate de grupo. Estudios Pedagógicos, 38(2), 187–200. https://doi.org/10.4067/S0718-07052012000200012*

[39] *Rodríguez, F., y Blanco, Á. (2021). Diseño de una secuencia de enseñanza-aprendizaje para el desarrollo de competencias científicas en el contexto del consumo de agua envasada. Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias, 18(1) 1803.https://doi.org/10.25267/rev_eureka_ensen_divulg_cienc.2021.v18.i1.1803*

[40] *Ruiz, K. y Espinosa Ríos, E. A. (2020). Fortaleciendo la competencia científica "identificar" en estudiantes de segundo grado a través de un ambiente de aprendizaje potenciado por TIC desde una perspectiva de la mediación didáctica. Investigações Em Ensino de Ciências, 25(1)159-191. https://doi.org/10.22600/1518-8795.ienci2020v25n1p159*

[41] *Sagástegui-Bazán, L. G. (2021). La metodología indagación y el aprendizaje de las Ciencias Naturales. Polo del Conocimiento, 6(12), 804-822.*

[42] *Sanmartí, N. y Márquez, C. (2017). Aprendizaje de las ciencias basado en proyectos: del contexto a la acción. Ápice. Revista de Educación Científica, 1(1), 3-16.https://doi.org/10.17979/arec.2017.1.1.2020*

[43] *Serrano, S., Duque, Y., y Madrid, A. (2015). La actividad investigativa en educación media. Representaciones de los profesores sobre las competencias científicas. Revista de Pedagogía, 35–36(97–98), 71–91.*

[44] *Tébar L., (2009) El profesor mediador del aprendizaje. Cooperativa Editorial Magisterio, Bogotá.*

[45] *Todd, Z. & Lobeck, M. (2004). Integrating survey and focus group research: A case study of attitudes of English and German language learners. In Z. Todd, B. Nerlich, S. McKeown, and D. Clarke (Eds.). Mixing methods in Psychology. Hove: Psychology Press.*

[46] *Torrecilla Sánchez, E. M., Olmos Miguelañez, S., y Rodríguez Conde, M. J. (2016). Efectos de la metodología didáctica sobre el aprendizaje de competencias para la gestión de conflictos en educación secundaria. Educación XX1, 19(2), 293-315. https://doi.org/10.5944/educXX1.13949*

[47] *Torres-Porras, J., & Alcantara-Manzanares, J. (2022). Are pre-service teachers able to answer children's questions about the natural sciences? Research Article. Journal of Turkish Science Education. 19(2), 374-388.*

[48] *Williams, U. J., & Dries, D. R. (2022). Supporting Fledgling Scientists: The Importance of Autonomy in a Guided-Inquiry Laboratory Course. Journal of Chemical Education, 99(2), 701-707. https://doi.org/10.3390/educsci11090475*