

# Experimentation in Times of COVID 19. Didactic Sequence “*Influence of pH on plant irrigation*” for a High School Chemistry Course

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**Abstract** This paper presents strategies that support the realization of experimentation in times that we cannot be in face-to-face situations in teaching laboratories. Experimentation and recreational activities, concept maps, bibliographic research, analogies, in combination with didactic readings were the main strategies on which it was supported for the realization of this work. It is exemplified by the didactic sequence “*Influence of pH on plant irrigation.*” with its respective didactic reading. The results of the exercise of evaluation and regulation of the learning obtained in a Course of High School Chemistry are also presented.

**Keywords:** *experimentation, didactic sequence, pH, plant irrigation, high school chemistry*

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## 1. Introduction

The educational landscape at all levels of the world’s educational institutions has been affected by the CoViD-19 pandemic, and Mexico is no exception. Likewise, the compliance of all academic institutions with health protocols prohibits offering face-to-face teaching; therefore, flexible learning has been resorted to that is supported by electronic means and learning activities at home. The flexible learning approach involves alternatives to face-to-face attendance in classrooms and labs that promote the collaborative learning environment of sequenced and directed or structured learning. Like the one proposed in this work that includes Experimentation, playful activities, concept maps, bibliographic research, analogies, in combination with didactic readings

### 1.1. Experimentation

Experiments in the classroom or laboratory are experiences promoted by the teacher to represent in an attractive way experiments or colorful and attractive changes so that, from it, explain a concept or introduce themselves to a certain topic. The expected effects on students are, capture their attention and then maintain their interest in their study and research that involves a

methodology that allows them to obtain results that allow meaningful learning [1].

To avoid that the activities in the classroom are tedious, we worked on the implementation of attractive and spectacular experimental strategies combining playful activities. These activities can contribute to develop the potential of students, adapting to the experience of the teacher, to contribute to the improvement of the educational process. It serves to develop learning processes and can be used at all levels or semesters, in formal and informal education. It is important not to confuse playful with play, since the game is playful, but not everything playful is game, it is also imagination, motivation, and didactic strategy. Experimentation and playful activities, in combination with didactic readings were the main strategies on which it was based for the realization of this work.

Didactic strategies based on spectacular experimentation and playfulness, are widely benefited with the development of practical experiences, in simple and reproducible experiments that can be combined with applications and structured games based on a specific thematic content. Play time is a time of learning [2] states that play allows the search for alternatives for the achievement of objectives, respect for rules, initiative, common sense, and solidarity with all those who participate. Likewise, it considers that the game, used as a resource in the educational process, allows the facilitator to know the

development of the child and to observe comprehensively the motor skill and affective and social behaviors; likewise, the participant experiences simulated situations of the adult's life and models their performance.

## 1.2. Playful Activities

The didactic game is a participatory teaching technique aimed at developing in students skills and competences in a fun environment, thus stimulating discipline with an adequate level of decision and self-determination; that is, it not only promotes the acquisition of knowledge and the development of skills, but also contributes to the achievement of motivation for the subject; that is, constitutes a form of teaching work that provides a wide variety of procedures for the training of students in decision-making for the solution of various problems [3].

The main objective when using this tool is to promote that the students of the upper secondary education relate more with chemistry and learn in a more fun and practical way with related topics on this subject.

The traditional way chemistry is presented to upper secondary students in general has not stimulated students to interact with their object of study and for many of them, it has only allowed them to perceive that subject as a science of difficult understanding and its study restricted to memorization [4].

Using didactic games such as the "chemical domino" the correlation between the name and formula of acids and bases can be highlighted. The "memory" game works the association between the level of acidity and the substance. The game helps them identify substances that are of the same chemical function [3]. The preliminary games showed that the use of the playful environment favors the discussion of the topic allowing the interaction between the students and of these with the teacher

## 1.3. Concept Maps

They are a technique that helps to order the knowledge acquired in a significant way so that every day it is used more in the different educational levels, from preschool to the university, in reports to research theses, used as a study technique to a tool for learning, since it allows the teacher to build with his students and explore in them the previous knowledge and the student to organize, interrelate and fix the knowledge of the content studied [5]. The concept mapping exercise encourages reflection, analysis and creativity.

Concept maps allow to organize concepts in a coherent way, their organizational structure is produced by significant relationships between concepts in the form of propositions, these in turn consist of two or more conceptual terms joined by words links that serve to form a semantic unity. In addition, the concepts are placed in an ellipse or box, the related concepts are joined by lines and the meaning of the relationship is clarified by the word's links, which are written in lowercase next to the lines of union. It should be borne in mind that some concepts are covered under other broader, more inclusive concepts, therefore, they must be hierarchical; that is, the more general concepts should be placed at the top of the map, and the less inclusive concepts at the bottom.

Concept maps allow teachers and students to exchange views on the validity of a given propositional link to finally provide a schematic summary of everything that has been learned [6] are useful tools to help students learn about the structure of knowledge and thought-building processes.

## 1.4. Bibliographic Research

Research is defined as an activity aimed at solving problems [7]. Its objective is to find answers to questions using scientific processes.

Bibliographic research is that stage of scientific research where it is explored what has been written in the scientific community about a certain topic or problem. What should be consulted, and how to do it?

For example: How to know the pH of the soil and its characteristics?

Bibliographic research: Although all soils have matter, plants do not grow in all of them in the same way, so we notice that in addition to different colors, some are presented with organic matter and microorganisms, diverse humidity and, analyzing more thoroughly, different salts and minerals distinguish them. Conducting research, we will find that a variable that affects the growth capacity of a crop in the soil is the pH.

The research methodology should be considered as an auxiliary discipline, within the chemistry program Students should be initiated into this type of activity so that they become familiar with the method of scientific work. Due to its conditions and demands of objectivity, spirit of observation, analysis, synthesis, reflection, and creativity, it is convenient to introduce this training within the teaching panorama [4].

## 1.5. Analogies

By analogy, the previous knowledge, and the new knowledge that the teacher will introduce to the class are related. Analogies serve to compare, evidence, learn, represent, and explain some object, phenomenon, or event [8]. Often teachers, without so planned, resort to the following analogies to facilitate the understanding of some concept: "they remember when we study", "I'm going to give you a similar example", "it's the same as", "because something similar happens here", or "this case is very similar to the previous one", are expressions that are heard in the classrooms, only in most cases their use obeys, as in everyday life, to spontaneity. There is no consciously planned application of analogy as a valuable resource for learning, which allows the student to understand the usefulness of it and its true scope.

In the field of learning, it can contribute to facilitating the understanding of relevant events. On the other hand, it is highly advisable to use several analogues and representational diagrams to promote communication and the transmission of knowledge [9]. The level of knowledge of the subjects will also determine the understanding of the analogy.

An example of the use of analogy was presented when a student in the classroom commented, when studying the pH scale and locating the ends of it in his own words: "If the opposite of the acidic is the base and in the middle part

is the neutral then it would be like understanding that the opposite of the bad is the good and the regular in the intermediate or in the cover of a clock the smallest scale is the one and the upper end is the twelve, the middle part would be the six.

## 1.6. Didactic Readings

The resource of promoting the reading of books or articles that summarize information and experiences that help the understanding of the phenomena and experiments reviewed in the classroom are a very useful tool and are enriched if they find factors that attract your attention, that is, that are recreational, informative, with practical and simple applications [10].

Reading is not an exclusive activity of the school environment, it is also an essential activity for the development of the individual; we read to respond to the need to live with others, to be able to communicate with the outside and to discover the information we need. Teaching to read is not a simple matter, but it is essential to promote in students its use in such a way that they allow them to interpret and understand written texts autonomously [11].

Reading as a means of communication, a form of learning and the possibility of creating new ideas presupposes language, information processing and processes related to teaching and learning.

Through language we can write and speak, reading and listening allows us to elaborate ideas, show them and reconstruct them [12]. Through language, knowledge is not only transmitted, but also created and recreated. Language shows us a way to participate in culture and constitutes a means of communication and learning.

Duchimasa-Ochoa and Huiracocha-Ordoñez [13] provide important elements for the understanding of reading; they agree that it is a process of interpretation and construction that presupposes the structuring of knowledge [14,15], that is, the organization of the set of previously learned experiences, which function as a guide for the understanding of other ideas and concepts that are acquired through reading.

The development of skills in students to summarize, synthesize and extend knowledge is greatly improved by reading [11]. They are very important skills because they allow us to extract main ideas, separate what is fundamental from what is not, elaborate summaries, etc. They are fundamental for learning because we could not understand all the information we handle when we want to learn, in fact, what we learn is a very specific part of that information, which we reach through a process of selection and omission of what does not seem fundamental to our purposes.

## 1.7. Didactic Sequence (DS)

Learning to learn, is the intellectual process that a person performs, to make sense of their cognitive abilities, it is a process that consists of realizing what one learns and how one learns it, it is to take all the knowledge acquired to use it for the benefit of oneself and others [15]. Learning to learn is to make the knowledge acquired meaningful, in such a way that you can use it effectively.

Education must not only enable the mastery of a "knowledge", but also that of a "know-how" and "knowing how to be", which in totality make up a more integral man, with a set of positive qualities of the personality, which identify him with his culture, beliefs, ideology, in short, with his national identity [16]. The three pillars of learning to learn are:

1) *Know*. It is to know one's own learning, to be able to reflect on the steps followed to achieve the understanding of certain concepts. Recognize the value of what is known and what is not known.

2) *Know-how*. It is to have the ability to apply in practice what has been learned, to make the learnings effective.

3) *Know how to be*. It is to be convinced of the usefulness of the acquired learning and to want to apply them. Be aware that everyone is responsible for the application of their knowledge and assume commitments. Break bonds of dependence.

In the teaching-learning process there is a planning or didactic sequence (DS) to achieve a better landing of the expected knowledge.

The DS is configured by the order in which the activities through which the teaching-learning process is carried out are presented. The emphasis will then be on the succession of activities, and not on the activities themselves.

The DS guides and facilitates practical development, it is a flexible proposal that couples the teaching-learning process to avoid improvisation and dispersion, considering the participation of students, teachers, the contents of the subject and the context [17], considering real times, resources, number of students, contextual variables, and previous knowledge. The DS is a didactic research instrument to the extent that it informs how the initial planning evolves and evaluates the usefulness of the selected strategies and informs the student of the changes in the knowledge achieved [15].

The DS that is addressed in this work for the study of acids and bases and the importance of pH knowledge for our daily lives, involves the stages of introduction, *construction of knowledge and closure* requiring 3 to 4 sessions of a couple of hours each, with the main purpose of achieving in the student a significant learning that links him with everyday life.

In each of the stages, the strategies to be used will be planned, always starting from previous knowledge, reaffirming this knowledge, and leading to more ambitious learning objectives, always starting from the simplest and moving on to the most complex after laying the foundations of the desired knowledge.

The expected objectives in each of the stages of the teaching-learning process (PTL) according to the DS addressed, involving the curricular issues that are raised in the chemistry II program of the curriculum del Colegio de Ciencias Humanidades UNAM (CCH).

## 2. Methodology

Strategy. "*Influence of pH on plant irrigation*".

Objective: To understand the influence of pH on plant irrigation.

The strategy was applied in two groups of the subject of Chemistry II, 26 students of group 205-B and the 37 of group ET41. With an average age of 17 years. In each group, teams of 5 to 6 members were formed, who carried out the strategy from their homes. Group sessions, to exchange experiences, results and obtain conclusions through were carried out through the ZOOM platform. 13 plants of the same species are prepared, with 50% vermiculite and 50% tezontle or some porous stone, each of them is identified, to monitor their development for 15 days with the irrigation of the different prepared solutions. Plant 13 is irrigated only with water. Various solutions of lemon juice are prepared, and liquid uncovers pipes according to Flowchart 1. The pH of each solution is measured.

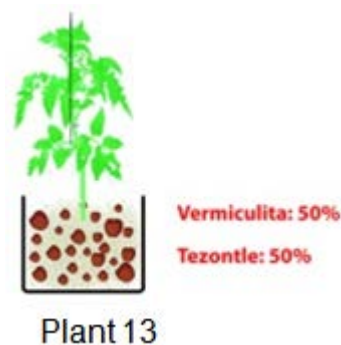
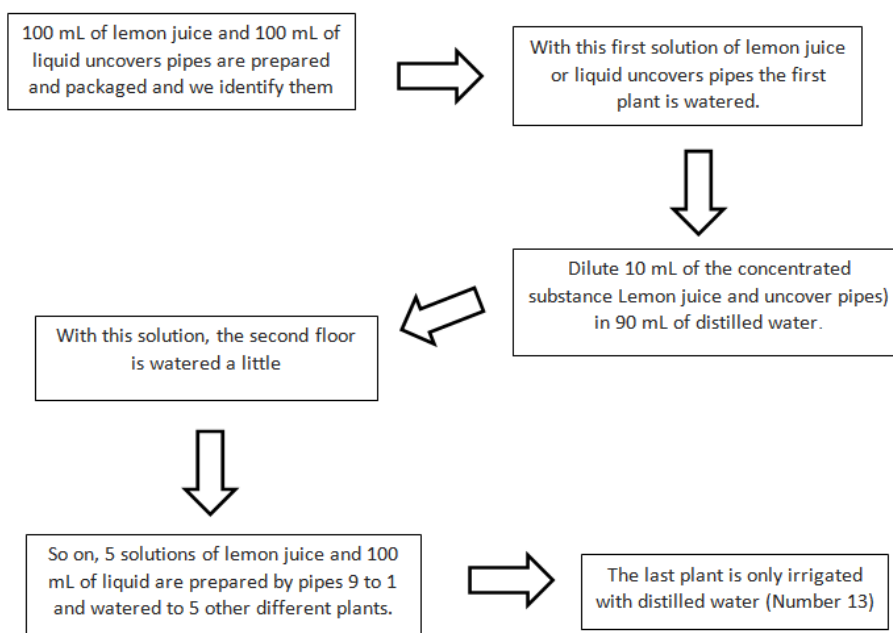


Figure 1. Identification of the control plant for irrigation at different concentrations of lemon juice and uncovering pipes



Flowchart 1. Preparation of solutions of lemon juice and liquid uncovers pipes

### 3. Results

We proceeded to form 6 teams of 6 and 7 members to discuss the observations made by all the teams. The results table presents in a general way the observations made by the group during the study period. The results are presented in Table 1, Table 2 and Table 3.

Table 1. Results with lemon juice watering

Plant	Solution pH	Day 1	Day 3	Day 6	Day 9	Day 12	Day 15
1	1 pH=1.42	The plant has not undergone changes	Loses leaves and turns yellowish	It loses leaves, does not grow and becomes more yellow	The plant is dry and with yellowish leaves	The plant is dead and dry	The plant is dry
2	2 pH=2.35	The plant has not undergone changes	Loses leaves and turns yellowish	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	The plant is dead and dry	The plant is dry,
3	3 pH=3.38	The plant has not undergone changes	Green leaves, does not grow	Loses leaves, does not grow and becomes yellowish	Lose all leaves	The plant is dead	The plant is dry,
4	4 pH=4.29	The plant has not undergone changes	Bright green leaves	Bright green leaves	Loses leaves and turns yellowish	Loses leaves and becomes more yellow	The plant is dead and dry.
5	5 pH=5.24	The plant has not undergone changes	Keeps stability	Bright green leaves	Bright green leaves	Loses leaves and turns yellowish	Loses leaves and becomes more yellow
6	6 pH=6.12	The plant has not undergone changes	Maintains stability and begins to grow	Maintains stability and begins to grow	Maintains stability and begins to grow	Maintains stability stays green and begins to grow	The plant continues as the first day tells us that plants can develop in a soil of pH 6

**Table 2. Results with the irrigation of uncovering pipes**

Plant	Solution pH	Day 1	Day 3	Day 6	Day 9	Day 12	Day 15
7	7 pH=12.52	The plant has not undergone changes	Maintains stability and begins to grow	Maintains stability and begins to grow	Maintains stability and begins to grow	Maintains stability and begins to grow	The plant continues as the first day tells us that plants can develop in a soil of pH 7
8	8 pH=11.45	The plant has not undergone changes	Maintains stability and begins to grow	Maintains stability and begins to grow	Maintains stability and begins to grow	Maintains stability and begins to grow	The plant continues as the first day tells us that plants can develop in a soil of pH 8
9	9 pH=10.46	The plant has not undergone changes	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	The plant turned yellow, lost leaves and life is dead on it
10	10 pH=9.38	The plant has not undergone changes	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	The plant turned yellow, lost leaves and life is dead on it
11	11 pH=8.25	The plant has not undergone changes	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	The plant turned yellow, lost leaves and life is dead on it
12	12 pH=7.22	The plant has not undergone changes	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	Loses leaves and becomes more yellow	The plant turned yellow, lost leaves and life is dead on it

**Table 3. Results with water irrigation**

Plant	Solution pH	Day 1	Day 3	Day 6	Day 9	Day 12	Day 15
13	13 pH=7.02	The plant has not undergone changes	Maintains stability and begins to grow	Maintains stability, green leaves and continues to grow	Maintains stability, green leaves and continues to grow	Maintains stability, green leaves and continues to grow	The plant continues as the first day tells us that plants can develop in a soil of pH 7

### 4. Discussion

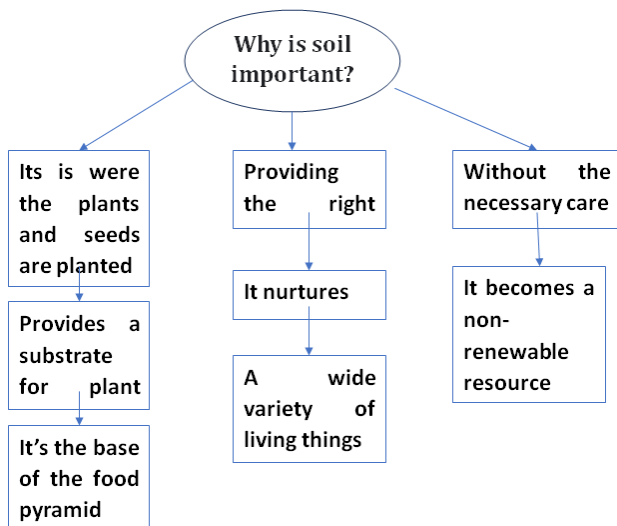
First, we ask students to analyze the didactic reading strategy *Why soil is important?* and establish their conclusions in a group way. To the question of what happened to the plant when watering them with solutions of different pH, it was concluded that the neutral pH or close to 7 is what favors the growth of the plants.

We asked if only with water could the plants survive and grow, the answers were mainly that yes, only that it depended on the quality of minerals that the earth contained since there are arid soils such as the desert that do not have the necessary minerals for the growth of plants and water in combination with minerals and the adequate pH are responsible for the growth of the plant since it allows to receive the necessary nutrients to survive. The closer the soil pH is to 7 the plant can easily grow if the pH is close to 0 or 14 the plant can die.

Extrapolating this experience to the life of the fish in the water, to the human being in their diet and general to any living being, the students concluded that the pH is a determining factor to preserve the health of every living being, so it is very important to take care of the adequate levels of pH in them.

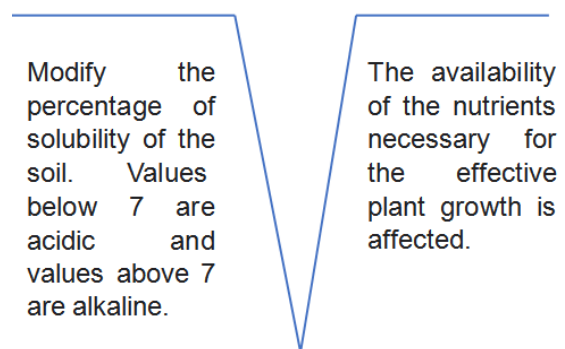
To close the topic the importance of pH in the following activity is highlighted, the students were asked individually to read the didactic reading about the topic "The pH in our life" (annex A), and present by group of 6 members a summary in Power Point extracting 10 important ideas to be analyzed as a team in class.

As a closing activity they were asked to create a conceptual map in which they synthesize the most important ideas about the importance of pH in the soil, elaborate a "V" of Gowin (Figure 3) and an exhibition before the group where these concepts are explained.



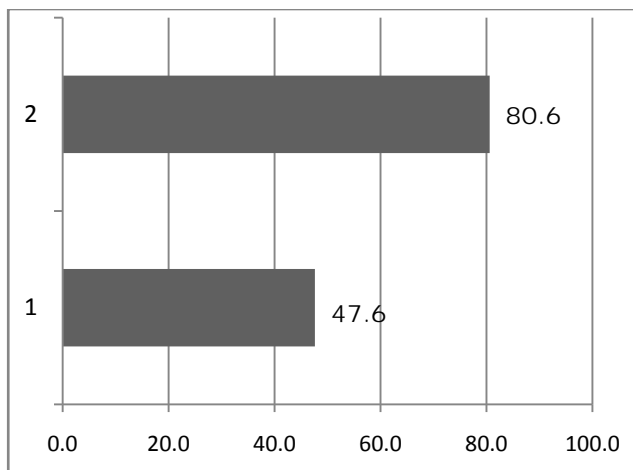
**Figure 2.** Didactic Reading Strategy

**What is the importance of pH in the soil?**



**Figure 3.** Gowin Diagram

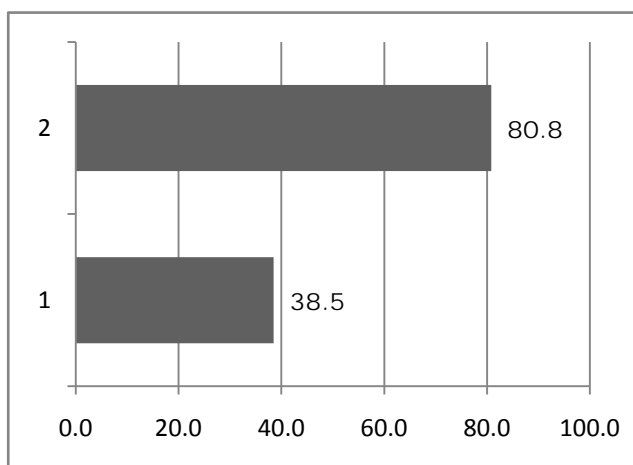
The effectiveness of the DS was assessed when comparing the general grades obtained by the 26 students of group 205-B and the 37 of group ET41 that were taken as a sample to apply the DS selected in this work. The results can be seen in Graphs 1 and 2.



Feedback:

1. Before applying the strategy, only 4 students had more than 60% of successes.
2. All the students had more than 70% of successes after applying the strategies proposed in this work.
3. The average results at the end of the application of strategies yielded an additional 69% efficiency with respect to the initial result.

**Graph 1.** Results of group 205-B (1.- Before applying the DS; 2.- After applying the DS)



Feedback:

1. Before applying the strategy, no student obtained more than 60% of successes.
2. All students had more than 70% of successes after applying the strategies proposed in this work.
3. The average results at the end of the application of strategies yielded an additional 110% efficiency with respect to the initial result.

**Graph 2.** Results of the ET41 group (1.- Before applying the DS; 2.- After applying the DS)

A previous questionnaire was applied (Table 4) before presenting the strategies developed in this work.

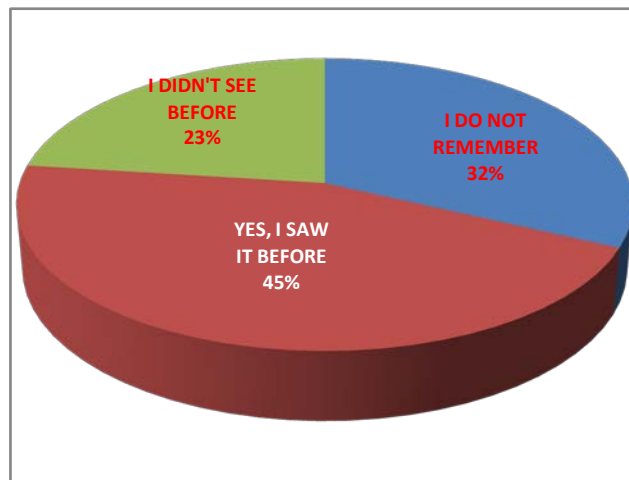
**Table 4.** Pre-topic questionnaire

item	Question
1	In previous courses, you had revised the topic of acids and bases?
2	Had you used the pH scale to measure the degree of acidity or alkalinity of a substance?
3	You found attractive the didactic proposal that was made about pH? according to the following terms: Interesting, motivating and fun.

A large percentage of students have low results in their knowledge in the subject, the main reasons for this

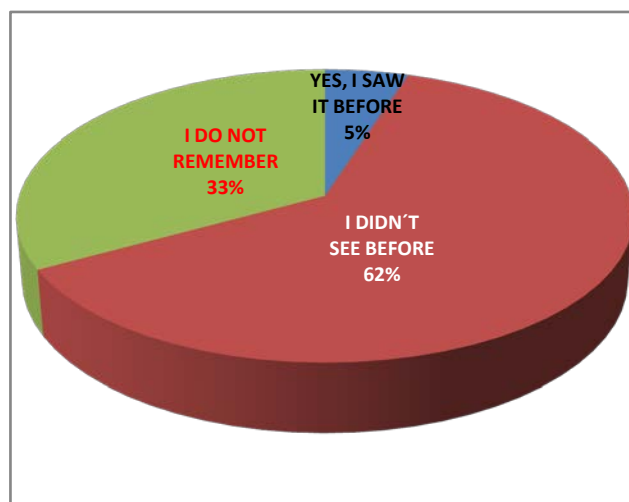
are summarized in graphs 3, 4 according to the question asked.

*In previous courses, had you revised the topic of acids and bases?*



**Graph 3.** Answers to question 1

*Had you used the pH scale to measure the degree of acidity or alkalinity of a substance?*



**Graph 4.** Answers to question 2

*You found attractive the didactic proposal that was made about pH? according to the following terms: Interesting, motivating and fun.*

The response was 100% satisfaction in all terms

Feedback:

The students comment that it is a very attractive way of learning that awakens their taste for learning chemistry because it allows them to learn by playing and does not seem boring or difficult as it seemed in other courses, in general they comment that in other subjects they could see some topics in this way and they would like to participate in them in this way, that is, playing and learning. It was observed that although the set of games does not allow the acquisition of all the expected knowledge, it is able to awaken interest in the study of the subject in a more peaceful way, making it possible to count on the use of teamwork, facilitating learning, stimulating cooperation and the socialization of knowledge and values of solidarity and cooperation.

## 5. Conclusions

The teachers are the center of attention of the students, in our hands is to interest them and boost their motivation to study the subject. Motivation or interest in something, for example, in chemistry, are feelings that are only learned if they are lived. If the teacher manifests it in class, either face-to-face, online and at a distance, the students perceive and value it.

As the activities planned in this work were carried out and the expectations began to be met in an integrative framework in the students, the environment was filled with initiatives and desires to participate actively, presenting creativity and enthusiasm in their participation both individually and in a collaborative team.

In most students there was a low motivation for the study of chemistry at the beginning of the course, which implies that the mere fact of attending is not a motivator for learning in these students, perhaps because they are not yet related to their academic results.

The chemistry class became a space of recreation and fun for the student, promoting active learning.

Activities were carried out that allowed to observe in an experimental way [15], [17] the effect of irrigation water to a plant when watering it with solutions of different pH, allowing students to reflect and conclude that the neutral pH or close to 7 is the one that favors the growth of plants.

Addressing topics with attractive experiments, which due to the Covid 19 pandemic, they were able to carry out at home, aroused interest in their study, allowing a greater approach of the student to Chemistry. After the application of the strategies and with the support of collaborative teamwork, the confidence and interest in the study of the subject was not only reflected in its results in the evaluation questionnaire, but also in its participation throughout the course, some comments from the students:

*until I understood this subject,*

*I like chemistry,*

*What else can we experience?*

*Could we raise this issue??, etc.*

From his comments it is observed that a significant change in the interest in his study was achieved.

Chemistry like all experimental sciences offer a great attraction for its study, you just must find that attractiveness for students to understand and apply it, regardless of their personal study preferences when choosing a university career.

We can see how the use of this methodology allows us to reach students more easily, awakening their interest in Chemistry and the acquisition of the contents in a simpler way, involving them from a constructivist perspective, in the teaching-learning process.

In this sense, the words of the American scientist and inventor, Benjamin Franklin, acquire special importance, with which he focuses the purpose of chemical magic experiments and didactic games in teaching:

*“Tell me and I forget, teach me and I remember it, get involved me and I learn it”*

It is important to recognize that most students have skills and attitudes for the study of experimental sciences, but if the environment in which the teaching-learning process is presented is not the most convenient for them, it promotes discouragement.

Teachers must promote motivational and creative factors without altering the established program or breaking with order in the classroom, aspects such as imagination, originality, curiosity, and entertainment should be encouraged in the classroom to promote creative thinking in them and better understand the relationship of these phenomena with their daily environment.

Achievement motivation, in the context of education, is the degree to which a student wishes to be successful. Bong [18] found that high- and low-achieving students in science at the high school level differed in that the former had a higher achievement motivation than the latter. In a study conducted in Mexico by [19], which addressed the relationship between achievement motivation and self-efficacy with school achievement in high school students, it was found that achievement motivation has positive implications on school achievement.

It is necessary to recognize that the training and preparation of the teacher never ends, and the updating of new teaching techniques will always be a point of continuous improvement in this process of attention to the improvement of school education.

This proposal can be made in schools that lack chemistry laboratories once we return to face-to-face classes.

With the results of this work, it is intended to motivate the reflection of teachers to attend their daily academic activities in an integral way, promoting creativity and application of knowledge in the daily life of the student, linking it with their environment to make them see the importance of the Chemistry in their personal training.

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## Annex A) Didactic reading

### The pH in our life

The pH is a simplified measurement scale, which indicates the acidity or alkalinity of a solution, pH means hydrogen potential. To measure the degree of acidity of a substance, the concept of pH was developed. The pH is a scale used to measure whether one substance is more acidic than another and vice versa. It has been determined that the pH of wet skin is around 5.5 so if we apply any cream or soap with a lower or higher pH it could cause irritation or burn. At a pH greater than 10 or less than 3, the skin could dissolve causing great damage. Knowing what the pH of the substances is very important for our safety against any chemical.

Acidity and alkalinity are 2 extremes that describe chemical properties. By mixing acids with bases, their extreme effects can be canceled or neutralized. The pH scale ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic can burn us. A pH greater than 7 is basic or alkaline, it can dissolve meat. The pH scale is logarithmic, which means that relative to a pH of 7, a pH of 6 is 10 times more acidic. A pH of 1 will be 100 times more acidic than a pH of 3. Some examples of acidic substances are lemon juice, vinegar, and muriatic acid. Bleach, milk of magnesia and ammonia are bases or alkaline substances.

### The pH in feeding

By eating food, we alter the pH of our body. The pH of our stomach is 1.4 due to the acid it contains, and which is useful for breaking down food. Some foods and their combinations can cause the stomach to generate more acid. If this happens too often, the acid could puncture the stomach causing an ulcer. Too much acid in the stomach it could escape into the esophagus and reach your mouth. This unpleasant sensation is known as heartburn. Combinations of acids and alkalis (bases) are automatically neutralized. To attack the acidity in the stomach, doctors recommend taking an anti-acid. Antacids are a base that neutralizes stomach acid producing improvement. Also baking soda has the same effect.

### The pH in your mouth

After brushing your teeth, the pH of the saliva in the mouth should meet a value around 7. That is, a neutral pH, which does not cause any damage to your teeth. If the pH is below 5.5, the enamel begins to get lost doing damage. If you eat any carbohydrate, such as bread or something that contains sugar, it will have the conditions to do more damage to your teeth.

### The pH in the blood

The pH in the blood remains in a narrow range between 7.35 to 7.45. The body maintains this narrow margin by using buffers, chemicals that can change indistinctly between two forms, a weak acid or a weak base. Shock absorbers are only temporary "substitutes" to prevent dramatic changes in the pH of the blood. Any significant change in the pH of cells is incompatible with life. For example, the pH of human blood is 7.4, and it must be kept within very narrow limits. If the blood becomes too acidified, the likely consequences are coma and death; excessive alkalinity results in overexcitation of the nervous system and even seizures.

Long-term correction of blood pH requires the kidneys to excrete the acid or base in the urine. For example, when the pH of the blood is low (acidic), the kidneys react by excreting more acid in the urine. The pH of the urine becomes more acidic until the pH of the blood returns to normal.

## THE pH in the skin

The pH of the skin is approximately 5.5 on average, varying slightly from one area of the body to another. This value can be maintained thanks to the sweat and sebum that are mixed on the body surface giving this pH. The good condition of the skin and hair will be maintained if this pH value does not undergo great variations. The indiscriminate use of products that transform it into alkaline means favoring the penetration into the skin of microorganisms and therefore the appearance of redness and various conditions.

## The pH in the field

If the pH of the soil/substrate is inadequate, the harvest may decrease to such an extent that it is not interesting to maintain the crop. In addition, it must be considered that there are waters whose carbonate or bicarbonate content can be very high (alkaline waters); their use, under sprinkler irrigation, can lead to significant problems if they have not previously been correctly acidulated. From all this it is important to know the pH of the nutrient solution that we use in irrigation. When the acidity of the soil changes, the solubility of the metal ions also changes. Plant growth is affected by the variable concentration of these metals in solution rather than by the acidity itself. Under acidic conditions, many soil minerals dissolve and the concentration of metal ions increases to toxic levels. The primary toxic metal is aluminum, but high levels of manganese and iron can also inhibit plant growth under these conditions. Phosphorus, molybdenum, and other nutrients are less available in acidic soils. Calcium and magnesium are also deficient. Under alkaline conditions, the solubility of minerals decreases causing nutrient deficiencies. Plant growth is limited by deficiencies in iron, manganese, zinc, copper, and boron. Phosphorus is also less available in alkaline soils and high levels of calcium can inhibit the absorption of potassium and magnesium.

## The pH in the environment

The pH of water affects terrestrial and aquatic life. Water from healthy lakes, lagoons and rivers generally has a pH between 6 and 8. Most fish tolerate water with pH between 6 and 9. More robust and strong fish usually die at lower and higher pH. Toads and other amphibians are more sensitive to pH than many fish. The pH of soil moisture affects the availability of nutrients for plants. Many plants prefer a slightly acidic soil (pH between 4.5 and 5.5), while others prefer a less acidic soil (pH between 6.5 and 7). Highly acidic soils (with a pH below 4.5) reach concentrations of chemical elements toxic to plants. Our body operates in the pH range of 7.0 to 7.8. Living organisms can survive only in a narrow range of pH change. When the pH of rainwater is less than 5.6, it is called acid rain. When acid rain flows into rivers, the pH of the river water is lowered. The survival of the aquatic life of these rivers becomes difficult.

## Acid Rain

Acid rain is one of the consequences of air pollution. When some fuel is burned, different chemicals are released into the air. The smoke from factories, the smoke that comes from a fire or that generated by a car, not only contains particles, it also has a large amount of gases highly harmful to our environment. Power plants, factories, machinery, and cars "burn" fuels, all are producers of polluting gases. These gases, especially carbon, nitrogen, and sulfur oxides, react with air moisture and are transformed into carbonic acid, sulfuric acid, nitric acid, and hydrochloric acid. These acids are deposited in clouds. All rain is always slightly acidic, as it mixes with oxides naturally in the air. Rain that occurs in places without pollution has a pH value of between 5 and 6. When the air is more polluted with nitrogen oxides and sulfur dioxide, acidity can reach a pH value of 3. Lemon juice has a pH value of 2.3.



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