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# Implementing a Didactic Strategy for Teaching Recyclable Plastic Polymers in High School Education

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**Abstract:** ***This study presents the design and application of a didactic sequence aimed at enhancing high school students understanding of recyclable plastic polymers. The proposed teaching strategy incorporates cooperative learning activities to identify different types of plastics, particularly recyclable ones. The goal is to increase student's scientific knowledge, enabling them to make informed decisions to mitigate environmental pollution caused by plastic waste. The study also addresses the research question: How can I recycle plastic materials in my everyday life to avoid contributing to environmental pollution***

**Keywords:** Didactic strategy, Recyclable plastic polymers, Teaching at high school education

## 1. Introduction

A didactic sequence is a series of teaching strategies potentially facilitating meaningful learning, of specific topics of conceptual or procedural knowledge (Obaya and Ponce, 2007), which can stimulate applied research in the daily teaching of classes. You can only talk about teaching when there is learning, and for learning to be considered as such, it must be meaningful In the didactic sequence that is proposed, the questioning of the teacher's narrative and the dialogue and criticism against the memorization of the students are privileged. At the beginning of the proposal, situations arise that lead students to externalize their previous knowledge of the subject to be treated, whether they agree with scientific knowledge. All these situations should be discussed in groups (Obaya, 1999), with the mediation of the teacher, stimulating participation. Cognitive progress consists of the development of a wide and very varied repertoire of schemes (Martínez et al, 2018), therefore, it is of utmost importance to evaluate their initial state (Obaya et al, 2019) through a previous questionnaire to review basic concepts.

## 2. Objective

Design and apply a didactic sequence for the learning of recyclable plastic polymers and increase the scientific knowledge of the high school student through activities that allow identifying different types of plastics and, of these, they are recyclable.

## 3. Hypotheses

By studying the didactic sequence on plastic recycling, the high school student will increase their scientific knowledge that will help them make decisions to reduce environmental pollution by plastic waste. Answering the *Research Question.* How can I recycle plastic materials in my daily life to avoid contributing to environmental pollution?

## 4. Justification

In general, High School students are not promoted a scientific education (Talanquer, 2006), they are not directed towards the understanding of science, nor is the ability to solve problems developed in them (Ruiz et al, 2019). For the realization of the research, the theme "Study of plastic polymers and their impact on today's world" of the subject Chemistry IV was chosen, which focuses on the Area of Experimental Sciences.

This subject at the upper secondary level is taught in the sixth semester of the Curriculum of the College of Sciences and Humanities of the National Autonomous University of Mexico (UNAM) in Mexico. It is an optional subject, selected both by students who will study careers in the Chemical-Biological area, and by students who choose careers in other areas of knowledge. It is relevant in terms of the search for environmental sustainability, so it is important to develop a didactic strategy that motivates the student to propose possible solutions on the recycling of plastic polymers and their use as raw material for the development of new products, at the level of Upper secondary education, identifying those materials that can be recycled and motivating the scientific curiosity of students.

## 5. Methodology

A didactic sequence (Table 1) with two classes, which includes a game: *The Questioning Ball* and an *Experimental Project: Obtaining Paint*, were elaborated based on the Unit "The study of polymers and their impact on the current world" of Chemistry IV of the College of Sciences and Humanities (UNAM).

With the following objectives where the student:

1) It will assess the importance of chemical synthesis in the development of materials that impact society in various areas.
2) You will understand that the properties of polymers depend on their molecular structure and that this

determines their multiple applications.

3) It will recognize the need to participate in the solution of the problem of environmental pollution by the disposal of polymeric materials, based on teamwork and through documentary and experimental research.

This study involved 20 students from the second semester of CCH Azcapotzalco UNAM, morning shift. Of these 15 are women and 5 men between 15 and 16 years old. In two classes of 2 hours each. To evaluate the effectiveness of the didactic sequence of "Recyclable plastic polymers for construction and other industries at upper secondary level" the previous knowledge possessed by the students was identified, through a questionnaire of 15 open questions. The questions are aimed at measuring the level of knowledge that students have about the subject of study. It questions the knowledge that students are intended to understand at the end of the implementation of the sequence. The exam is the same that is applied both at the beginning of the strategy and at the end of it and for practical purposes, they are distinguished as pretest and posttest. These are described in detail in Annex A.

**Table 1:** General presentation of the lesson plan developed to address the topic of polymer

| | ***LESSON PLAN*** | | |
|---|---|---|---|
| **SEMESTER** | Sixth | **CLASS** | **Number 1** |
| **SUBJECT** | Chemistry IV | DURATION | 120 minutes |
| **UNIT** | | UNIT II. The study of polymers and their impact today. | |
| **THEME** | | • Polymerization reactions (addition and condensation)<br>• Classification of polymers by origin (natural and synthetic) | |
| **PURPOSES** | | Value the importance of chemical synthesis in the development of materials that impact society.<br>Know the polymers by their classification to facilitate their recycling. | |
| **GENERAL OBJECTIVE**<br>**Know the classification of polymers by their origin (natural and synthetic) and explain the difference between addition polymerization and condensation polymerization.** | | | |
| **LEARNING TO ACHIEVE**<br>**The student:**<br>**You will understand that the reactivity of a monomer is due to the presence of double, triple or functional group bonds.**<br>**Recognizes the differences between addition and condensation polymerization.**<br>**It recognises the importance of polymers in everyday life, reflecting on the natural and synthetic origin of materials and their applications.** | | PRIOR KNOWLEDGE<br>Chemical bonding.<br>Chemical reaction. | |
| **SUBTOPIC** | | Uses of polymers | |
| **OBJECTIVE OF THE SUB-THEME** | | Understand that the properties of polymers depend on their molecular structure and that this determines their multiple applications. | |

**Initiation Phase**

| | |
|---|---|
| TIME: 5 min. /_<br>Presentation of the teacher, the topic to be addressed and the objectives. | |
| TIME: 15 min. /_ | TECHNIQUE: |
| PREVIOUS QUESTIONNAIRE | Questionnaire. |
| It begins with a questionnaire, which will be delivered individually to the students for their solution. | MATERIAL:<br>Printed questionnaire, blackboard, markers. |
| Purpose of the activity: to know the previous conceptions of the students related to the subject. | |
| What is a polymer? | |
| What is a monomer? | |
| How are polymers obtained? | |
| In which objects do we find polymers in our daily lives? | |
| Define what an addition polymerization reaction consists of. | |
| What type of reaction is PET obtained? | |
| What is a plastic? | |
| What is the difference between a thermoplastic plastic and a thermosetting plastic? | |
| What are single-use plastics? | |
| What are microplastics? | |
| What effect do microplastics have on humans? | |
| What is recycling? | |
| What is reuse? | |
| What number corresponds to the identification of polystyrene in the products that are made with it? | |
| Do you know any recycling method? | |

**Development Phase**

| | |
|---|---|
| ***TIME: 80 min. /***<br>***A POWER POINT PRESENTATION IS MADE ON:***<br>***1. Classification of polymers by their origin (natural and synthetic) and uses of polymers.***<br>***2. Polymerization reactions (addition and condensation)***<br>***3. THE VIDEO IS PROJECTED POLYMERS.***<br>***https://www.youtube.com/watch?v=9jw4p_0e9j4***<br><br>***ACTIVITY: CROSSWORD PUZZLE***<br><br>***Learning Objectives: The student:***<br>***You will understand that the reactivity of a monomer is due to the presence of double, triple or functional group bonds.***<br>***Recognizes the differences between addition and condensation polymerization.***<br>***It recognises the importance of polymers in everyday life, reflecting on the natural and synthetic origin of materials and their applications.***<br>***Purpose of the activity: That students understand the importance of double and triple bonds and functional groups, in the synthesis of polymers, their uses and classification in a general way.*** | TECHNIQUE:<br>Presentation<br>Students will be asked to participate. Material: Projector. Computer.<br>notebook, pencil, blackboard, markers, etc. |
| ***CLOSURE PHASE*** | |
| ***TIME:20 min. /***<br>***A final evaluation will be applied with the same initial questionnaire and the results will be projected. This activity is passed for the second class of polymers.***<br><br>***Purpose of the activity: Evaluate the knowledge acquired and be able to compare it with respect to previous knowledge.*** | TECHNIQUE:<br>Questionnaire<br>MATERIAL:<br>Questionnaire<br>RECOMMENDATIONS:<br>Take the average at the end, |
| | |

| | | | |
|---|---|---|---|
| | **LESSON PLAN** | | |
| **SEMESTER** | Sixth | **CLASS** | **Number 2** |
| **SUBJECT** | Chemistry IV | DURATION | 120 minutes |
| **UNIT** | | UNIT II. The study of polymers and their impact today. | |
| **THEME** | | Identification of polymeric materials by their code. Methods for recycling polymers based on their type and composition. | |
| **PURPOSES** | | Value the importance of chemical synthesis in the development of materials that impact society.<br>Recognize the need to participate in the solution of the problem of environmental pollution by the disposal of plastic polymers. | |
| **GENERAL OBJECTIVE**<br>**Identify methods for recycling polymers based on their type and classification.** | | | |
| **LEARNING TO ACHIEVE**<br>**The student:**<br>**Recognises the importance of making responsible use of plastic polymer materials in everyday life, by reflecting on the reasoned and conscious use of them, classifying them so that they can be recycled efficiently.** | | PRIOR KNOWLEDGE<br>What is a Polymer? What is a monomer? | |
| **SUBTOPIC** | | Paint manufacturing | |
| **OBJECTIVE OF THE SUB-THEME** | | Offer recycling alternatives for plastic polymers. | |

**Initiation Phase**

| | |
|---|---|
| **TIME: 5 min. /**<br>**Presentation of the teacher, the topic to be addressed and the objectives.** | |
| **TIME: 15 min. /** | TECHNIQUE: |
| **PREVIOUS QUESTIONNAIRE** | Cuestionario. |
| **It begins with a questionnaire, orally asking** | |
| **questions in a general way, to be answered by the** | MATERIAL: |
| **group.** | |
| ***Purpose of the activity*: Remember what was seen** | Printed questionnaire, blackboard, markers. |
| **in the previous class on the subject.** | |
| 1) What is a polymer? | |
| 2) What is a monomer? | |
| 3) How are polymers obtained? | |
| 4) In which objects do we find polymers in our daily lives? | |
| 5) Define what an addition polymerization reaction consists of. | |

| | |
|---|---|
| 6) What type of reaction is PET obtained? | |
| 7) What is a plastic? | |
| 8) What is the difference between a thermoplastic plastic and a thermosetting plastic? | |

**Development Phase**

| | |
|---|---|
| ***TIME: 80 min. /_***<br>***A POWERPOINT PRESENTATION IS MADE, WHICH INCLUDES TWO VIDEOS:***<br>***THE HISTORY OF PLASTIC.***<br>***https://www.youtube.com/watch?v=Cz-OZyK9M_Q HOW to eliminate microplastics from your hygiene and beauty routine?***<br>***https://www.youtube.com/watch?v=yvjl1fauydo***<br><br>***Discussion is promoted and questions are asked about the topics addressed.***<br><br>***Questioning ball***<br><br>***Purpose of the activity: Identify the participants.***<br>1) Break the tensions of the first moment.<br>2) Facilitate everyone's participation.<br>3) That students awaken the interest in knowing the importance of polymers.<br>***Group size: all group participants Development of the technique.***<br>1) Students are placed in a circle (Conditioned by the workplace)<br>2) The teacher will write the questions to be answered on the board.<br>3) The ball is thrown by the teacher at random.<br>4) The participant who has kept the ball must read the question aloud and before answering it will say his name. The game continues in the same way until the questions are over. In case the same person keeps the ball again, another question is chosen.<br><br>***Learning Objectives: The student***<br>***Argue the need to make responsible use of polymeric materials and measures you can take as citizens to help reduce environmental pollution from the disposal of these materials.***<br><br>***Experimental phase: the teacher will explain the procedure to be followed during the laboratory practice. Students will obtain a glue and paint from polystyrene waste (single-use polymers). Their results and observations are recorded, then an analysis of results is made to draw conclusions about the experimental development.*** | ***TECHNIQUE: The questioning ball (Annex B).***<br>***Students will be asked to participate.***<br>***Material:***<br>***Projector.***<br>***Computer.***<br>***A ball.***<br>***notebook, pencil, blackboard, markers, etc.***<br>***Obtaining paint (Annex C)***<br>***MATERIAL***<br>***Solvent (Thinner)***<br>***Additives (Vinyl Paint Sealant)***<br>***Polystyrene (waste)***<br>***Pigments***<br>***Calcium carbonate Water.*** |

**Closure Phase**

| ***TIME:20 min.*** | ***TECHNIQUE: Questionnaire*** |
|---|---|
| A final evaluation will be applied with the same initial questionnaire as Class 1 Purpose of the activity: Evaluate the knowledge acquired and be able to compare it with respect to previous knowledge. | *MATERIAL: Questionnaire, which covers the two classes that cover the topics presented and which is essentially the same that was presented as a diagnostic examination.* |
| 1) What is a polymer? | *RECOMMENDATIONS: Take the average at the end,* |
| 2) What is a monomer? | |
| 3) How are polymers obtained? | |
| 4) In which objects do we find polymers in our daily lives? | |
| 5) Define what an addition polymerization reaction consists of. | |
| 6) What type of reaction is PET obtained? | |
| 7) What is a plastic? | |
| 8) What is the difference between a thermoplastic plastic and a thermosetting plastic? | |
| 9) What are single-use plastics? | |
| 10) What are microplastics? | |
| 11) What effect do microplastics have on humans? | |
| 12) What is recycling? | |
| 13) What is reuse? | |
| 14) What number corresponds to the identification of polystyrene in the products that are manufactured with it? | |
| 15) Do you know any recycling methods? | |

## 6. Results

The strategy of the "*questioning ball*" is used as a resource to socialize, enter confidence, showing empathy for the student. In this way it will be easier to encourage the participation of students, to know what they know about the subject, your strengths, weaknesses, abilities, and expectations. The pretest

aims to know how much the students know about the subject, some questions that caught their attention:

1) What is a polymer?
2) What is a monomer?
3) What is a plastic?
4) Difference between thermoplastic and thermoset.
5) What are single-use plastics?
6) What is recycling?

Table 2 show some of the answers provided by students in the pretest based on the results of this test, the students' knowledge was limited. Most of the questions were not answered or were not answered incorrectly.

**Table 2:** Some answers from the initial pretest

| Question | Student | Answer |
|---|---|---|
| **What is a polymer??** | A | It is a substance with many molecules. |
| | B | Plastic materials. |
| | C | Chemical compound whose molecules are formed chains that are repeated a basic unit |
| **What is a monomer?** | A | It is a substance with few molecules. |
| | B | It's a single. |
| | C | Simple molecule of low weight. |
| **What is a plastic?** | A | A petroleum derivative |
| | B | It is a material. |
| | C | No response. |
| **Difference between thermoplastic and thermoset** | A | The heat capacity they can recieve. |
| | B | That one endures higher temperature. |
| | C | No response. |
| **What are single-use plastics?** | A | Those that only have a shelf life. |
| | B | That they can only be used once. |
| | C | No response. |
| **What is recycling?** | A | No response. |
| | B | That can be converted into an equal object. |
| | C | No response. |

Of course, if the topic is polymers, your interest is focused on *What is a polymer and how is it obtained? When asked where do we find polymers in our daily lives?*

Their answers were basically in everything plastic, associating polymers as a synonym for plastic. There were also those who mentioned proteins as a polymer, which indicates that some had a greater knowledge on the subject. To all this, a question arises by way of reflection.

*Can we live without polymers today?*
The answer to one voice was "NO", but they immediately agreed to make rational use of plastic polymers, to engage in research into environmentally friendly plastics and biodegradable materials.

At this time, we cannot imagine a world without plastic polymers, because these are used for the manufacture of many products, practically everything in our daily lives.

When asked about recycling and reuse, most answered that recycling is transforming an object into a different one by some method, while reusing is using that object, for a different use than it was originally designed.

Which indicates that if they had well differentiated terms. In the case of recycling, they only had some theory, nothing put into practice. They only stayed in the part of separating the most common materials such as PET bottles, aluminum containers, and cardboard that they knew could be recycled.

The activities that have to do with the preparation of the painting kept the interest of the students from beginning to end. It explains how the practice will be carried out. A written procedure is given to each team indicating the steps to follow and the health risks of each substance used. Team building fosters the spirit of camaraderie and facilitates work, creating an environment where they cooperate with each other instead of seeking personal show. While some dissolve and mix the polystyrene with thinner and sealant, another team prepares the calcium carbonate paste and one more dissolve the pigment. Finally, a mixture is formed with all of them, to obtain the paint. It is very important to always supervise by the teacher to avoid unwanted situations. As such the product obtained is also a polymer, one that we obtain from garbage and that we will use protecting our house from moisture and solar radiation. It is a product in experimentation, to which you must make modifications in the dosage of the ingredients and test, to work the one that gives us the best results. Finally, the paint prepared on a board is tested, to see the tone, the body (that it is not very diluted), that it has good application, etc. According to their comments, they find it very interesting, since the degradation time of polystyrene in the environment is 500 to 800 years (information they investigated on their own) and in the experiment we degraded it in minutes.

Finally, when asked. *Do you know any method to recycle plastic polymers?*

Some said that you could make clothes with the bottles, others that you could make bottles again, but that they would not know how to do it. Finally, someone said – "make paint and if you knew how to do it, then we just did it."

In the closing phase of the didactic strategy, students are asked to answer the posttest Table 3, which is the same as the pretest.

**Table 3:** Some answers from the posttest

| Question | Student | Answer |
|---|---|---|
| **What is a polymer?** | A | It is a set of monomers |
| | B | Substance composed of large molecules or macromolecules |
| | C | A substance composed of large molecules or macromolecules. |
| **What is a monomer?** | A | Small molecules. |
| | B | It is a simple molecule. |
| | C | Simple molecule and joined together form a polymer. |
| **What is a plastic?** | A | A polymer. |
| | B | Material composed of organic or synthetic compounds, its main property is to be malleable. |
| | C | Material composed of organic or synthetic compounds, its main property is to be malleable. |
| **Difference between thermoplastic and thermoset** | A | The times they can be molded. |
| | B | Thermoplastics: They can be remolded and reheated, as many times as desired.<br>Thermosets: They do it only once. |
| | C | Thermoplastics: They can be remolded and heated.<br>Thermosets: They do it only once. |
| **What are single-use plastics?** | A | Those that are used and discarded. |
| | B | That they can only be used once. |
| | C | They are plastics that are designed for single use. |
| **What is recycling?** | A | Transform a product. |
| | B | That can be converted into an equal object. |
| | C | Collect the largest amount of raw material (plastic) and create another container or product. |

The purpose of this questionnaire is to evaluate the knowledge acquired during the strategy, for this the previous exam is taken as a reference making the comparison with the posttest (final exam) and determines the progress of each student.

According to the results of the final exam, we can say that the strategy applied, in the presentation of the topics contributed to a higher academic performance of the students.

During the experimental part of the proposed didactic sequence some recommendations are made:

1) During the process of dissolution of the unicell (polypropylene), first, the sealant is placed in the container that we are going to use, followed by dissolving the unicell with the thinner, stirring constantly until the three substances are completely integrated, forming a homogeneous viscous substance in a single phase. At this point it could be used as glue or as a waterproofing. The thinner with the unicell forms a paste, which by itself is not useful since the new polymer that is formed (the paint), basically part of the reaction of polystyrene with the components of the sealant.
2) Everything that involves the work of dissolving polystyrene, must be done inside the extraction hood or in a well-ventilated place, because the vapors generated are toxic.
3) Due to the characteristics of the paint as a final product, it is recommended only for exteriors. Aeration favors drying and dispersion of vapors.
4) Calcium carbonate is prepared in a separate container. Put the amount of carbonate indicated in the procedure and add little by little the water stirring, to facilitate the formation of a uniform paste, taking care not to form lumps.
5) To the pigment that comes in powder, we add a little water, enough to make it liquid and facilitate its incorporation into the previous mixtures.
6) Finally, the pigment is integrated with the calcium carbonate and the latter to our first mixture. Which results in a good quality painting.

To the express question of can we manufacture our own paint?

The answer was yes, and they can modify the quality by moving the variables involved, that is, the quantities of the ingredients, the color can be more intense or less intense depending on what they want. Not only that they can also get other products such as glue and waterproofing, pastes from wood sawdust, for ornaments, and everything else they can imagine. This project is in an experimental stage. However, the idea of reducing the waste generated by polystyrene containers and packaging was welcomed by the students.

## 7. Analysis of the results

When analyzing the results of the pre-exam (Figure1), we have the following results:

1) Only four students had passing grades being the highest 6.3, representing 20% of the students sampled.
2) There is a group average of 4.3.
3) We had six students with a grade of less than three, with the minimum grade being 2.0, representing 30% of the sample.
4) In general, there were grades below the minimum pass, which indicates that 80% of students have very little knowledge about the subject.
5) The most repeated rating value ranges from 2.0 to 2.7
6) The graph marks the accepted grade limits (Specification limits: inferior LIE and superior LSE) what can be seen is that at that time the students do not have enough knowledge to pass the subject and it is necessary to implement a strategy, so that the educational process is directed in the direction of the expected results.

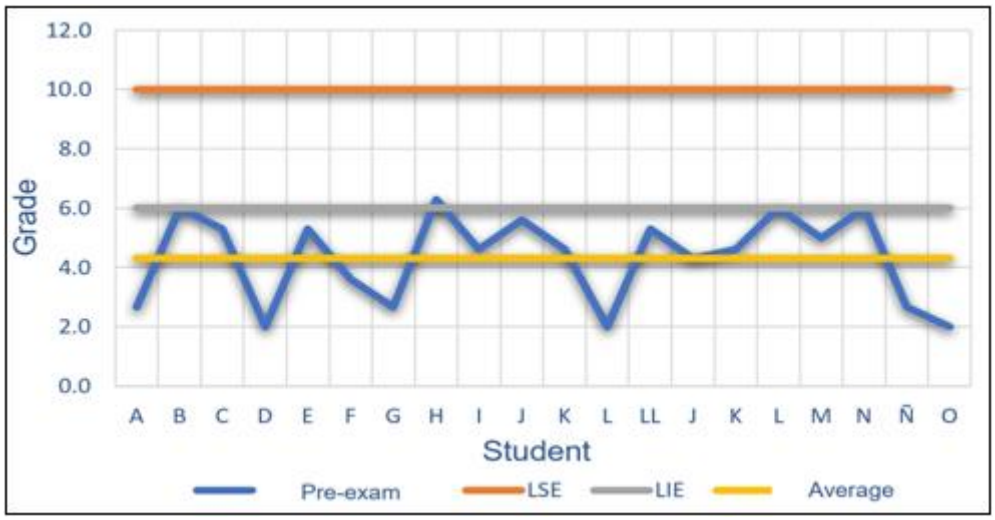


**Figure 1:** Pretest results

Once the didactic strategy was applied, the results changed considerably (Figure2), the following results are observed:

1) Four students scored the highest, including one student with a grade of 10.
2) There is a noticeable improvement; the average group rating is 8.9.
3) 4 students with the minimum grades, but in this case the minimum grade was 8.0, much higher than the maximum value of the previous exam which was 6.3.
4) There were grades, which exceed the expected average specification (8.0), this indicates that their level of knowledge on the subject increased.
5) The most repeated value is 9.0.
6) The didactic strategy implemented yielded very good results.

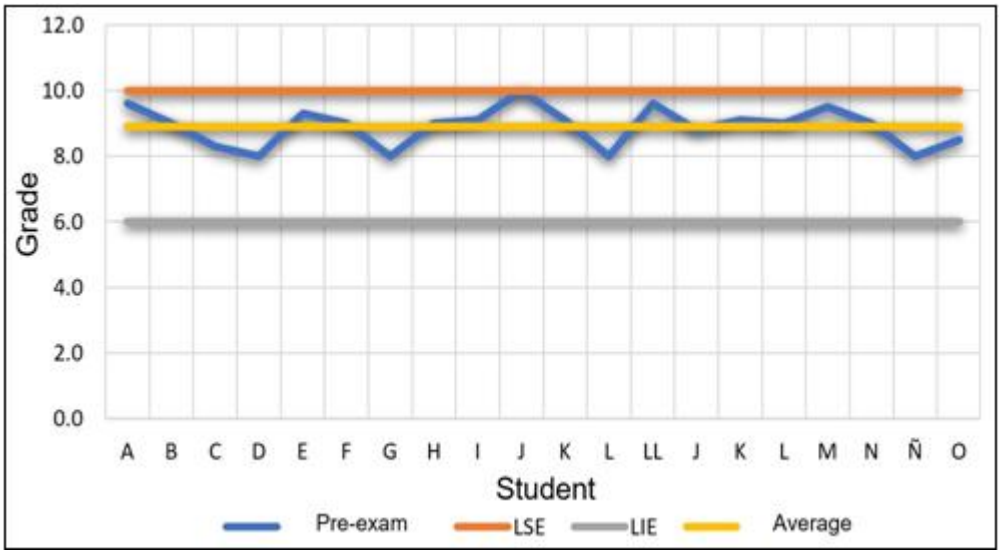


**Figure 2:** Posttest results

The comparison between pretest and posttest is shown in Figure 3.

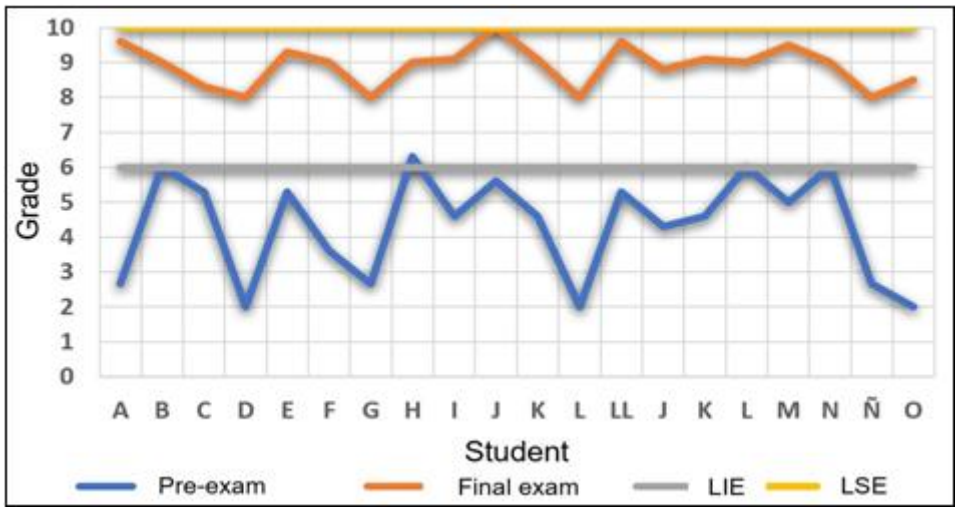


**Figure 3:** Comparison of pretest vs posttest

## 8. Conclusions

There are important problems in the teaching of science, students only to fulfill repetitive and irrelevant tasks and activities, where they do not investigate or reflect, they are not directed towards the understanding of sciences, nor is the ability to solve problems developed in them, in general a scientific education is not promoted in them (Giammatteo and Obaya, 2018). Students are immersed in a sequencing of topics that is arbitrary to them: they hardly feel motivated to study them.

The topic of "Study of plastic polymers and their impact on today's world", of Chemistry IV of the CCH is relevant in terms of the search for environmental sustainability, so it is important to teach learning to motivate the student to propose possible solutions on the recycling of plastic polymers and their use as raw material for the development of new products at the upper secondary level. To improve the understanding of the topic, a contextualization strategy was implemented. Through situations that lead students to externalize their previous knowledge of the subject to be treated (Palacios and Obaya, 1997) through the cooperative learning strategy

Care must be taken that the material to be presented has a logical meaning that is easy to relate the new knowledge with previous knowledge, with relevant ideas that facilitate the understanding of the subject. From there, in the development stage, a PowerPoint presentation is made where it is explained what a chemical reaction is, polymerization reactions, definitions of monomer and polymer, their classification and uses.

In the second session, two short videos are presented, and the game of the questioning ball is used, which allows us to contextualize the knowledge of the class with everyday experiences.

In this game, a reflection is made on the need to recycle our garbage and change our consumption habits that lead us to the reduction of single-use plastics, as well as the need to continue working on the research of biodegradable polymers.

In the experimental stage, paint is manufactured from polystyrene garbage, a recycling procedure that reduces the degradation time of polystyrene from hundreds of years to minutes.

As a teaching project it is interesting and allows us to transfer to our students in a practical way the contents collected in the subject of Chemistry. The proposed experiments and demonstrations help them to recognize the importance and presence of chemistry in our daily lives, as well as to begin to face the phenomena that surround them with scientific thinking. It should be noted that to carry out the experiment such as the one exposed in this work, very complicated materials, or chemical reagents difficult to achieve are not necessary.

Finally, the students felt comfortable in the class, which gave them the confidence, to actively participate in the practice. The results of the research are favorable there is a noticeable change in the grades of the exam prior to the final exam. With this result it is concluded that these activities can be applied in teaching practice and the sequence is useful to raise the level of use in the subject of polymers. Likewise, recognize the need to participate in the solution of the problem of environmental pollution by the disposal of polymeric materials, based on teamwork and through documentary and experimental research.

The final evaluation helps us to analyze the schemes developed by the students after the implementation of the proposed sequence. This evaluation includes the evidence of significant learning achieved during the development of the activities carried out and will allow the pertinent adjustments to be made to the didactic sequence according to the results obtained.

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### Annex A: Pre and Posttest Questionnaire

Polymerization reactions and classification of polymers by their origin

Name and surname_Date_____

Group_

Answer briefly what is asked of you.

1) What is a polymer?
2) What is a monomer?
3) How are polymers obtained?
4) In which objects do we find polymers in our daily lives?
5) Define what an addition polymerization reaction consists of.
6) What type of reaction is PET obtained?
7) What is a plastic?
8) What is the difference between a thermoplastic plastic and a thermosetting plastic?
9) What are single-use plastics?
10) What are microplastics?
11) What effect do microplastics have on humans?
12) What is recycling?
13) What is reuse?
14) What number corresponds to the identification of polystyrene in the products that are manufactured with it?
15) Do you know any recycling methods?

### Annex B. Activity *The Ball Questioning*.

**Objectives:**

1) Identify participants,
2) Break the tensions of the first moment,
3) Facilitate everyone's participation.

**Development**

1) Before the event, questions regarding the objective are noted on the board.
2) The teacher arranges the participants in a circle, introduces himself by mentioning his name and where he sees himself in the next 3 years. Throw the ball to one of the students, who must introduce himself and say where it is visualized in 3 years and answer the first question written on the board.
3) The continuous game, the next student must do the same routine before answering the question and passing the ball to the next student (this chosen at random).
4) The teacher directs the process, so that the group analyzes how what they have learned can be applied to their daily lives.

### Annex C: *Laboratory Project*

**Process for the Manufacture of Paint from Waste Polystyrene**

**Objective**

Awaken scientific curiosity in high school students by presenting a proposal for recycling plastic polymers, which allows them to obtain useful products from waste, in an orderly and safe way.

**Scope**

This procedure is in the experimental phase, it is presented for didactic purposes for high school students, so it is limited to obtaining small amounts of paint that can be used in its entirety. It is not recommended to manufacture it for commercial purposes.

**Safety**

This activity must be developed in an extraction hood and at all times supervised by the teacher. See the following link. https://www.comex.com.mx/getattachment/099e5714-6f43-470e-b82a-f5ec97236fdf/.aspx/

Development. Safety equipment: Dressing gown.

Latex gloves. Safety glasses. Spatula.

*Materials to use*: Solvent (Thinner)
Additives (Vinyl Paint Sealant) Polystyrene (waste)

Pigments (color for cement). Calcium carbonate.
Water.

- Clean the polystyrene as well as possible, leaving it free of food debris and dust.
- Premixed (sealant, Thinner and polystyrene),
- In a 3 liter bucket add 0.5 L of sealant for vinyl paint.
- Add the polystyrene and dissolving simultaneously with 0.5 L of thinner (added by drip), dissolve piece by piece, to facilitate its incorporation with the sealant. It is continued until obtaining a liquid with a thick consistency. Up to this point the product obtained works like a glue. Let stand while the other mixtures are prepared.
- Preparation of calcium carbonate mass
- In a plastic container of 3 L are placed 0.5 kg calcium carbonate.
- Add water little by little and mix, to prepare a dough. Do not add excess water, it is necessary that the product has the consistency similar to that of the dough to prepare corn tortillas. Let stand for a few minutes while the pigment is prepared.

***Preparation of pigment***

- In a plastic container of 1 L place the measure of 3 tequila glasses
- Add water little by little, until the pigment has a liquid consistency.

***Final mixing***

- Add the pigment obtained in step 4 to the calcium carbonate mass in step 3 and mix until homogenized.
- Add to the previous mixture, the premix (sealant, thinner and polypropylene) from step 2. It continues to mix until it has a consistency characteristic of a commercial paint. The product obtained is mixed to avoid dispersed pigments.

***Application***

The application of paint on a wooden surface is carried out to see characteristics; color, adhesion, body.