SEVEN
publicações acadêmicas

A SUSTAINABLE APPROACH TO HIGH SCHOOL EDUCATION: BIOPLASTICS IN CHEMISTRY EDUCATION – PART II

UMA ABORDAGEM SUSTENTÁVEL PARA O ENSINO MÉDIO: BIOPLÁSTICOS NO ENSINO DE QUÍMICA – PARTE II

UN ENFOQUE SOSTENIBLE PARA LA EDUCACIÓN SECUNDARIA: BIOPLÁSTICOS EN LA EDUCACIÓN QUÍMICA – PARTE II

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ABSTRACT

This study aimed to promote environmental awareness among high school students through a didactic sequence exploring bioplastics made from corn starch, integrating chemical concepts with reflections on sustainability. The qualitative and exploratory research was conducted with a class of 34 students at the Federal Institute of Pernambuco – Ipojuca Campus, and involved the application of pre- and post-intervention questionnaires to analyze the evolution of knowledge regarding polymers, conventional plastics, bioplastics, and environmental impacts. The methodology included theoretical lessons, debates, and experimental activities aligned with the Science, Technology, and Society (STS) approach. The results demonstrated a significant improvement in the understanding of the concepts covered, highlighting the connection between theory and practice. The laboratory synthesis of bioplastic proved to be a highly effective teaching resource, promoting student engagement and consolidating learning. All participants reported a stronger connection between theoretical content and its everyday applications. Most students showed awareness of the importance of bioplastics as a sustainable alternative, emphasizing their biodegradability and renewable origin, but also pointed out challenges, such as production costs and technical limitations. It is concluded that the inclusion of socio-environmental topics in Chemistry education, combined with active methodologies, strengthens students' critical thinking and broadens their awareness of sustainable solutions. The study highlights the importance of innovative pedagogical practices that link science to real-world issues, preparing students for informed and responsible decision-making in the face of contemporary environmental challenges.

Keywords: Bioplastic. Chemistry Education. Environmental Education.

RESUMO

Este estudo teve como objetivo promover a conscientização ambiental entre alunos do ensino médio por meio de uma sequência didática que explora bioplásticos produzidos a partir de amido de milho, integrando conceitos químicos a reflexões sobre sustentabilidade. A pesquisa, de natureza qualitativa e exploratória, foi realizada com uma turma de 34 estudantes do Instituto Federal de Pernambuco – Campus Ipojuca, e envolveu a aplicação de questionários pré e pós-intervenção para analisar a evolução dos conhecimentos sobre

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polímeros, plásticos convencionais, bioplásticos e impactos ambientais. A metodologia adotada incluiu aulas teóricas, debates e atividades experimentais alinhadas à abordagem Ciência, Tecnologia e Sociedade (CTS). Os resultados demonstraram um avanço significativo na compreensão dos conceitos abordados, destacando a relação entre teoria e prática. A síntese laboratorial de bioplástico se mostrou um recurso didático altamente eficaz, promovendo o engajamento dos alunos e consolidando o aprendizado. Todos os participantes relataram maior conexão entre o conteúdo teórico e suas aplicações cotidianas. A maioria dos estudantes demonstrou percepção acerca da importância dos bioplásticos como alternativa sustentável, ressaltando sua biodegradabilidade e origem renovável, mas também apontou desafios, como custos de produção e limitações técnicas. Conclui-se que a inserção de temas socioambientais no ensino de Química, aliada a metodologias ativas, fortalece a formação crítica dos estudantes e amplia sua conscientização sobre soluções sustentáveis. O estudo reforça a relevância de práticas pedagógicas inovadoras que aproximem a ciência de problemáticas reais, preparando os alunos para tomadas de decisão fundamentadas e responsáveis frente aos desafios ambientais contemporâneos.

Palavras-chave: Bioplástico. Ensino de Química. Educação Ambiental.

RESUMEN

Este estudio tuvo como objetivo promover la conciencia ambiental entre estudiantes de secundaria mediante una secuencia didáctica que explora los bioplásticos producidos a partir de almidón de maíz, integrando conceptos químicos con reflexiones sobre la sostenibilidad. La investigación cualitativa y exploratoria se llevó a cabo con una clase de 34 estudiantes del Instituto Federal de Pernambuco, campus Ipojuca. Se aplicaron cuestionarios antes y después de la intervención para analizar la evolución del conocimiento sobre polímeros, plásticos convencionales, bioplásticos e impactos ambientales. La metodología adoptada incluyó clases teóricas, debates y actividades experimentales alineadas con el enfoque de Ciencia, Tecnología y Sociedad (CTS). Los resultados demostraron un progreso significativo en la comprensión de los conceptos abordados, destacando la relación entre la teoría y la práctica. La síntesis de bioplásticos en el laboratorio resultó ser un recurso didáctico muy eficaz, que promovió la participación del alumnado y consolidó el aprendizaje. Todos los participantes reportaron una mayor conexión entre el contenido teórico y sus aplicaciones cotidianas. La mayoría de los estudiantes comprendió la importancia de los bioplásticos como alternativa sostenible, destacando su biodegradabilidad y origen renovable. Sin embargo, también destacaron desafíos como los costos de producción y las limitaciones técnicas. La conclusión es que la incorporación de temas socioambientales en la enseñanza de la química, combinada con metodologías activas, fortalece el pensamiento crítico de los estudiantes y aumenta su conciencia sobre soluciones sostenibles. El estudio refuerza la importancia de prácticas pedagógicas innovadoras que acerquen la ciencia a los problemas del mundo real, preparando a los estudiantes para tomar decisiones informadas y responsables ante los desafíos ambientales contemporáneos.

Palabras clave: Bioplásticos. Enseñanza de la Química. Educación Ambiental.

5 RESULTS AND ANALYSIS

The analysis of results in innovative pedagogical practices in the teaching of Chemistry should be based on the search for meaningful and contextualized learning. As Cruz and Neto (2018) point out, educational activities that connect scientific concepts to students' daily lives have greater potential to engage them and promote critical reflection on socio-environmental problems. In this sense, Santos and Schnetzler (2010) highlight that interdisciplinary and contextualized strategies are fundamental to make scientific content more attractive and understandable, especially in themes related to sustainability.

In addition, according to Moreira (2011), significant learning occurs when the new content is related to the student's previous knowledge, integrating with their cognitive structures in a lasting way. This process is particularly effective in methodologies that favor active interaction between student and content, such as those proposed by the Science, Technology and Society (STS) movement, which seeks to connect science and technology to contemporary challenges (Auler & Bazzo, 2001).

5.1 DIDACTIC SEQUENCE

The role of the proposed didactic sequence (DS) is to make the teaching about bioplastics, aligned with the content of Chemistry, a process that arouses curiosity, being attractive and instigating in the classroom, being connected to themes that articulate the syllabus to everyday knowledge, inserted in a social, technological and environmental dimension. The main objective was to introduce the theme in a contextualized and interdisciplinary way, providing students with significant learning as the specific content dialogues with the students' previous knowledge, allowing a dialogue that enables the assimilation of new conceptions, ideas and understandings.

During the application of this DS, we sought to analyze the factors that contributed to the success or failure of the proposal, considering both the difficulties faced by the teacher and the students' responses. Among the positive aspects, the interest and motivation of the students throughout the class stand out, demonstrated through questions, reports and discussions. The active involvement of many students was noticeable, who were able to relate the topic of bioplastics to their daily lives, especially with regard to sustainability and the reduction of the environmental impact caused by conventional plastics.

On the other hand, a negative aspect observed was the lack of engagement of a small portion of the students. Although DS is designed to instigate and motivate, not everyone has shown continued interest in the topic. This highlights the need to improve pedagogical

strategies that can more effectively reach the different learning profiles present in the classroom.

In the theoretical classes, it was possible to notice the initial excitement of the students when they were introduced to the theme. The interdisciplinary approach, which connected concepts of Chemistry and environmental issues, aroused the curiosity of many. The interaction was marked by questions both directed by the teacher and spontaneously carried out by the students themselves. Practical examples, such as the explanation of the theme related to the problem of synthetic plastics, the damage to the environment, the life cycle of bioplastics and their application in packaging and biodegradable products, were key points for involvement.

In practical activities, such as the synthesis of bioplastics from corn starch, the interest was even more evident. The students showed enthusiasm when handling the materials and observing the chemical process, which facilitated the understanding of the theoretical concepts previously discussed. This practical step proved to be essential to consolidate learning and encourage the application of knowledge in a critical and reflective way.

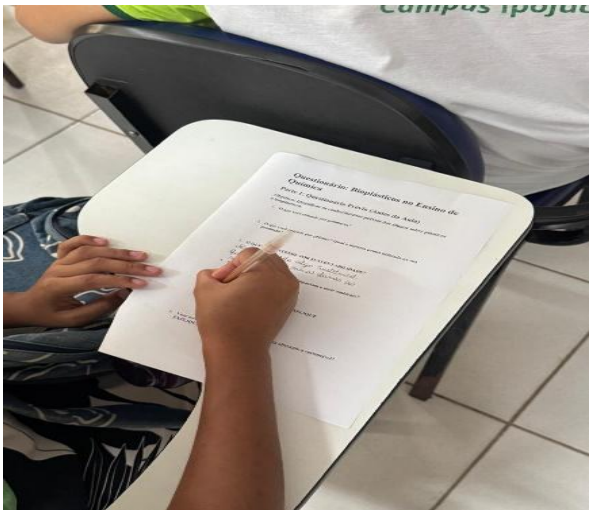
The theme of bioplastics, due to its contemporary relevance and interdisciplinary potential, contributed to stimulate the students' critical sense in relation to environmental problems and possible scientific solutions. However, the challenges faced reinforce the importance of planning even more dynamic and personalized didactic sequences, capable of meeting the demands of a diverse classroom.

5.2 FIRST STAGE – PRELIMINARY TEST

The initial stage of the pedagogical intervention consisted of the application of a diagnostic questionnaire to the students, with the objective of investigating their previous knowledge about polymers, plastics, bioplastics and sustainability. The application of this instrument was essential to understand the students' initial conceptions, identify possible conceptual gaps and support the structuring of subsequent activities (Figure 2).

Figure 1

Pre-test



Source: The Author (2024).

According to Bardin (2011), content analysis starts from a preliminary reading of the data collected, allowing the organization and categorization of responses in a systematic way. This process contributes to the construction of an overview of the students' understanding before the intervention, enabling an approach that is more aligned with their educational needs.

5.2.1 Second Stage – Pedagogical Intervention

After the application of the initial questionnaire and the analysis of the students' answers, the pedagogical intervention was carried out through a didactic sequence structured to address the concepts of polymers, plastics, bioplastics and sustainability. This intervention aimed to broaden and deepen the students' knowledge, promoting meaningful and contextualized learning (Figure 3).

Figure 2

Pedagogical Intervention

Source: The Author (2024).

The approach adopted included dialogued lectures, discussion of environmental problems related to the use of synthetic plastics, case analysis and a practical activity of synthesis of bioplastic from corn starch. This set of strategies sought to connect the theoretical content to the students' reality, stimulating critical thinking and reflection on sustainable alternatives in the context of chemistry and society.

During the intervention, different reactions from students were observed, ranging from increased interest in the topic to questions about the feasibility of using bioplastics on a large scale. As Ausubel (2003) points out, meaningful learning occurs when new information is integrated into students' previous knowledge, allowing a deeper understanding of the content. Next, the records of this stage are presented through images and descriptive analyses, evidencing the involvement of students in the teaching-learning process.

Continuing the pedagogical intervention, a practical activity was carried out aimed at identifying and classifying polymers present in everyday packaging. The objective of this activity was to provide students with an interactive experience, connecting the theoretical contents to the reality of the disposal and recycling of plastic materials (Figure 4).

Figure 3

Packaging present in the students' daily lives

Source: The Author (2024).

Each group of students received different plastic packaging, such as PET bottles, bags, yogurt jars and food containers. The task consisted of locating the symbology of recycling on the labels (Figure 5). And identify the corresponding polymer type by associating it with the plastic identification table. Then, the students went to the board and recorded the numbering of the polymers found, promoting a collective mapping of the types of plastic analyzed (Figure 6).

Figure 4

Location on labels

Source: The Author (2024).

Figure 5

Collective mapping of polymer numbering

Source: The Author (2024).

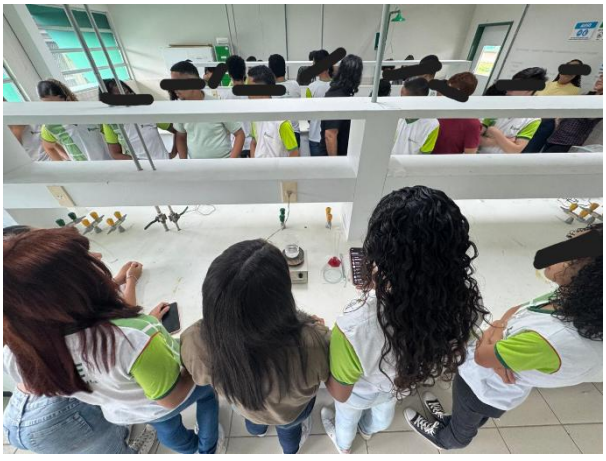
This dynamic enabled a discussion about recycling, the durability of polymers in the environment and the importance of choosing biodegradable materials. In addition, the activity stimulated the active participation of students, making learning more meaningful.

5.3 BIOPLASTIC SYNTHESIS **– PRACTICAL EXPERIENCE IN THE LABORATORY**

After the theoretical activities, an experimental practice was carried out in the laboratory for the production of bioplastic from corn starch. This stage aimed to reinforce the concepts previously discussed, allowing students to experience in practice the synthesis of a biodegradable polymer produced from renewable and sustainable raw material (Figure 7).

Figure 6

Explanation of the practice in the laboratory

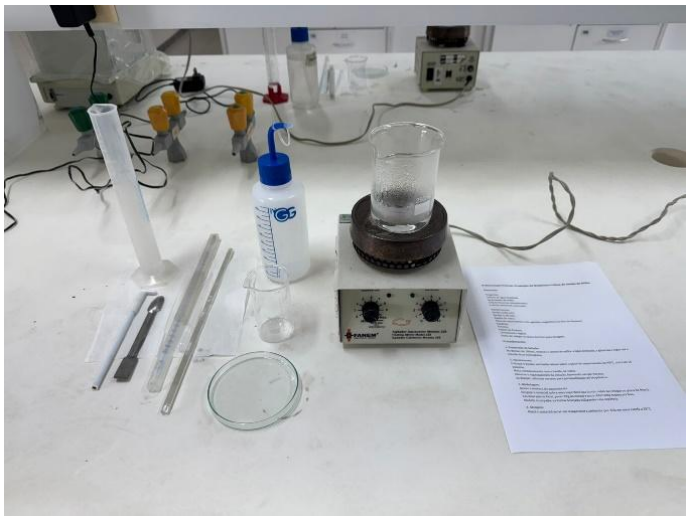


Source: The Author (2024).

The activity began with an explanation of the role of starch as a raw material for the production of bioplastics, highlighting its properties and environmental advantages. Then, the students followed the experimental procedure using corn starch, water and food coloring. This experience allowed them to understand the formation of the polymeric material and the factors that influence its properties (Figure 8).

Figure 7

Experimental procedure

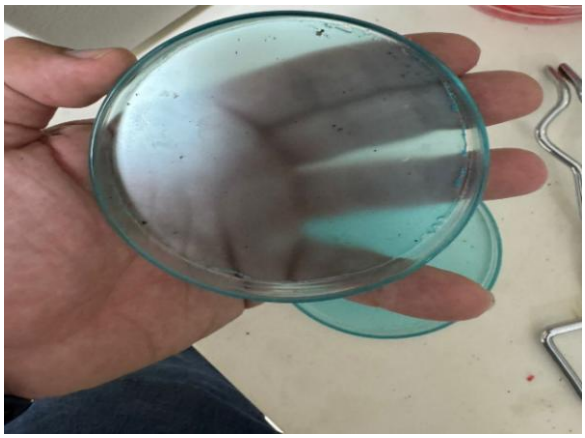


Source: The Author (2024).

The involvement of the students was remarkable throughout the activity. The excitement at seeing the bioplastic taking shape (Figure 9), the curious questions about the reactions and the smiles when handling all the material, demonstrated the positive impact of the experience. The joy of seeing the theory materializing in practice (Figure 10) was palpable, which contributed to a more meaningful and pleasurable learning.

Figure 8

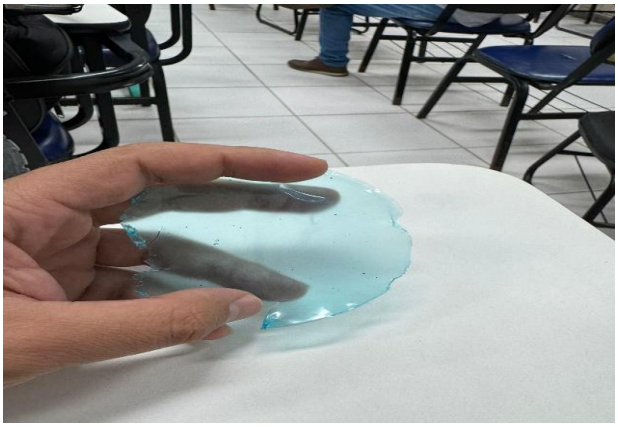
Bioplastic being formed



Source: The Author (2024).

Figure 9

Final sample: Bioplastic Synthesis



Source: The Author (2024).

In addition to consolidating technical learning about polymers, the experience also generated reflections on the feasibility of bioplastics as a sustainable alternative. Students actively participated, raising questions about their industrial applications, biodegradation and environmental impact compared to conventional plastics.

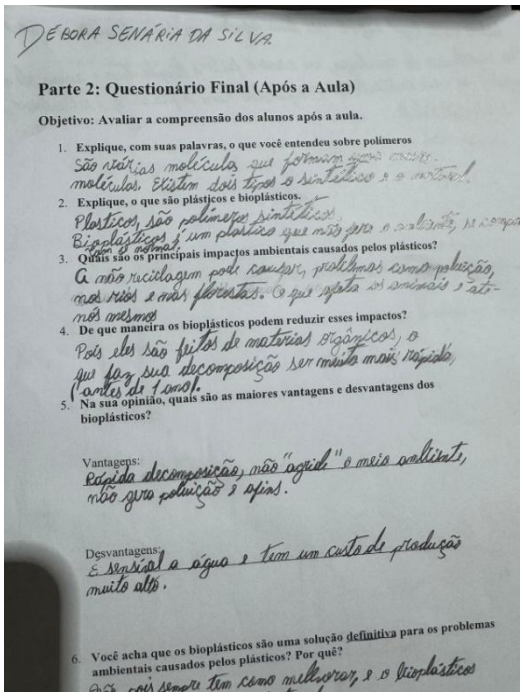
5.4 FINAL QUESTIONNAIRE

After the practice in the laboratory, the students returned to the room to answer the final questionnaire. This stage aimed to evaluate the evolution of learning, comparing the knowledge acquired with the initial perceptions raised in the previous questionnaire. In addition, it allowed to identify the impact of the pedagogical intervention on the understanding of bioplastics, sustainability and their applications. During this phase, the students reflected

on the practical experience, highlighting the main learnings and clarifying possible doubts, thus consolidating the knowledge built throughout the didactic sequence (Figure 11).

Figure 11

Final Questionnaire



DÉBORA SENÁRIA DA SILVA

Parte 2: Questionário Final (Após a Aula)

Objetivo: Avaliar a compreensão dos alunos após a aula.

1. **Explique, com suas palavras, o que você entendeu sobre polímeros**
São várias moléculas que formam [illegible] moléculas. Existem dois tipos o sintético e o natural!
2. **Explique, o que são plásticos e bioplásticos.**
Plásticos, são polímeros sintéticos. Bioplásticos é um plástico que não gera o [illegible]
3. **Quais são os principais impactos ambientais causados pelos plásticos?**
A não reciclagem pode causar, problemas como poluição, nos rios e mar florestas. O que afeta os animais e até nós mesmos.
4. **De que maneira os bioplásticos podem reduzir esses impactos?**
Pois eles são feitos de matérias biológicos, o que faz sua decomposição ser muito mais rapida, [illegible] partes de 1 ano!
5. **Na sua opinião, quais são as maiores vantagens e desvantagens dos bioplásticos?**

Vantagens:
Rápida decomposição, não "agride" o meio ambiente, não gera poluição e afins.

Desvantagens:
É sensível a água e tem um custo de produção muito alto.

6. **Você acha que os bioplásticos são uma solução definitiva para os problemas ambientais causados pelos plásticos? Por quê?**
[illegible] tem como melhorar, e o bioplásticos

Source: The Author (2024).

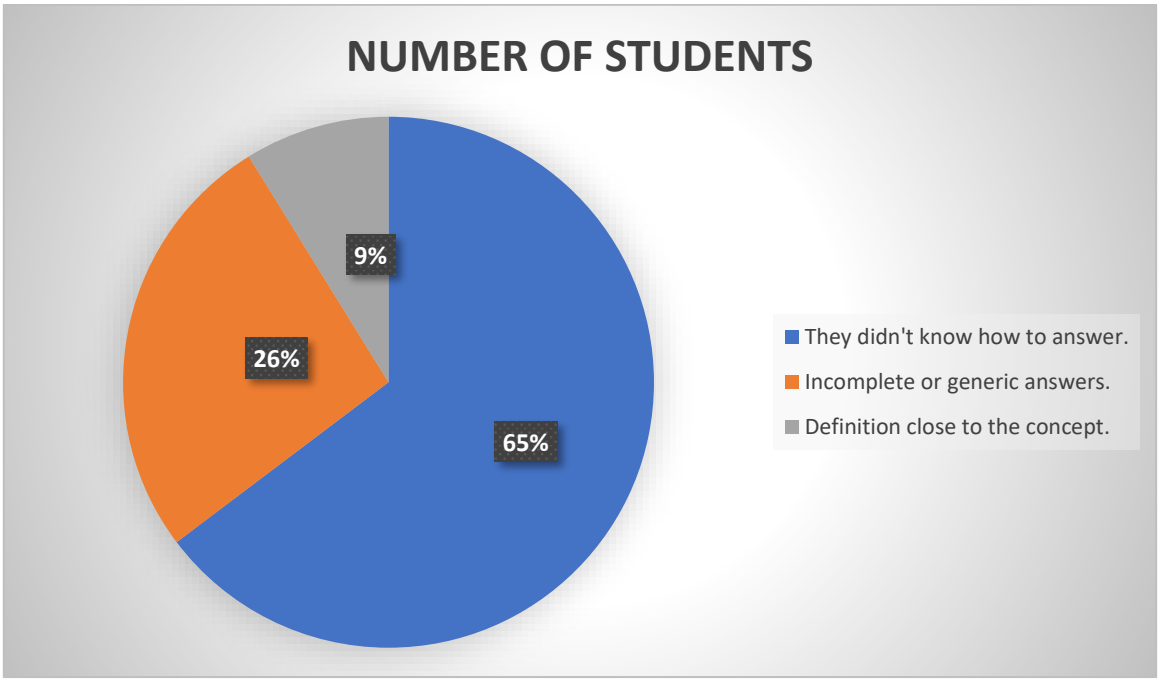
5.5 FIRST STAGE – PRIOR SURVEY OF KNOWLEDGE

The initial stage of the study consisted of the application of an open questionnaire with six questions directed to 34 students, with the objective of investigating their previous knowledge about polymers, plastics, bioplastics and sustainability. This approach was essential to capture students' initial perceptions, serving as a starting point for understanding their knowledge gaps and aligning future pedagogical interventions. As highlighted by Bardin (2011), preliminary reading plays a fundamental role in content analysis, allowing a better organization and interpretation of the data collected. In addition, this step contributes to identifying response patterns and directing the planning of more effective educational strategies. Next, the results are presented through graphs and detailed analyses, To facilitate the analysis of the data, it was decided to use two complementary graphs. The first graph presents an overview of the percentage distribution of students' answers to the question (Figure 12). This representation in pie chart format allows a quick reading of the relative proportions of each response category. The second graph (Figure 13), on the other hand, breaks down these same data, but in absolute numbers, that is, showing the exact number of students who selected each answer. This breakdown is essential for a more accurate

interpretation, as it allows visualizing not only the proportions, but also the real impact of each category in terms of the number of students who demonstrated knowledge or lack of knowledge on the subject, facilitating the visualization and understanding of the data obtained.

Figure 10

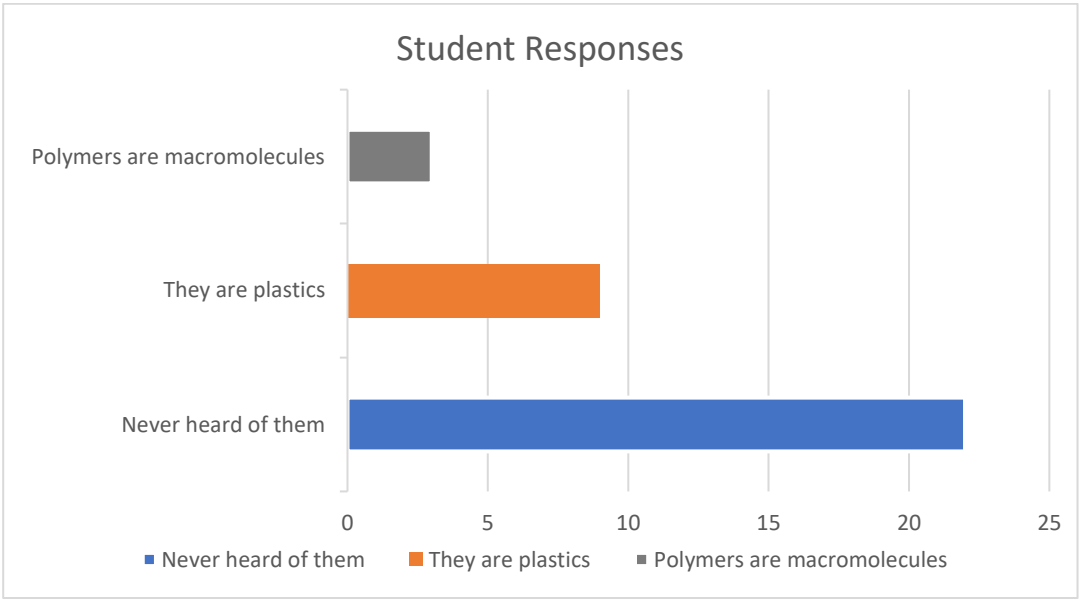
1st question: What do you mean by polymers?



Source: The Author (2024).

Figure 11

Student responses



Source: The Author (2024).

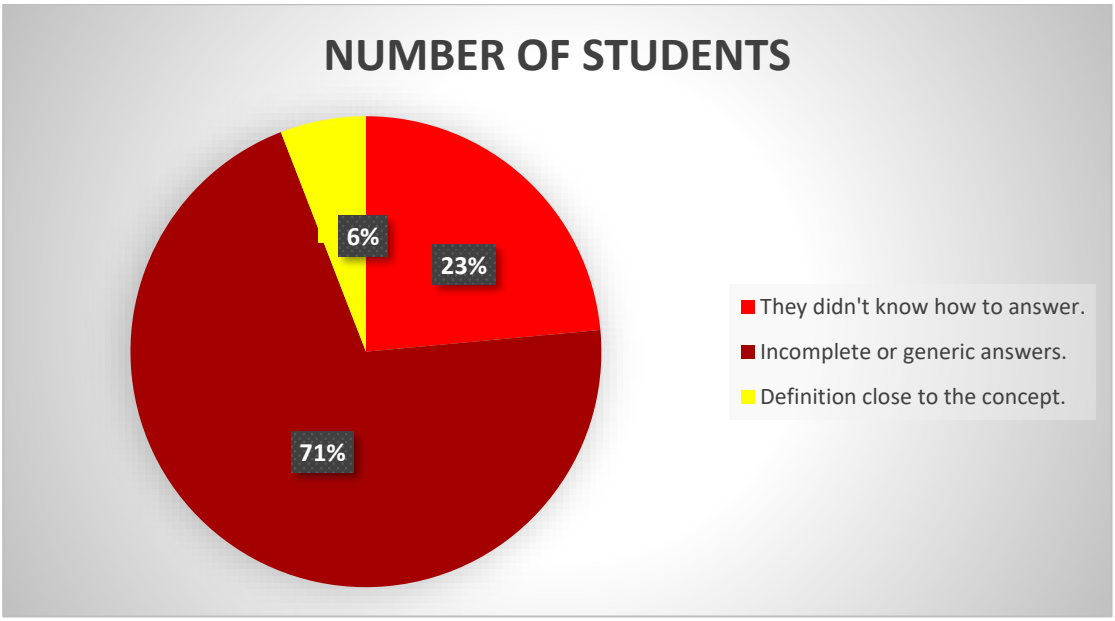
The results show that 26% of the students presented generic or incomplete answers. One aspect observed was the association of the polymer with plastic, being described as "something used to make plastic" or "a type of chemical material", in addition to the mention of petroleum as the raw material for the polymer. Another 65% did not know how to answer the question, while only 9% offered answers close to the concept. Three of the answers drew attention for indicating the polymer as a "macromolecule", one as a "large chain" and another quite curious, in which the student mentioned "several numbers". In this case, the lack of a specific vocabulary made the individual mobilize simple resources to express his idea of "union of monomers", observing the mention of "long chains of repetitive molecules".

This variety in responses, in particular the association of polymers with plastics, suggests that students bring previous conceptions to the classroom, even if they are poorly founded or unrelated to consolidated theories. This factor can be of great value in teaching strategies, especially in the previous survey of students' ideas, and can serve as a starting point for Chemistry classes and expanding discussions on specific topics.

Even so, a large contingent of students is still unable to conceptually establish the ideas that will be worked on, evidencing the need for more careful planning, which favors contextualized teaching associated with their daily lives. The sustainability approach, using the properties and uses of polymers as a programmatic theme, can be an effective strategy to make teaching more meaningful and bring the contents closer to the students' reality.

Figure 12

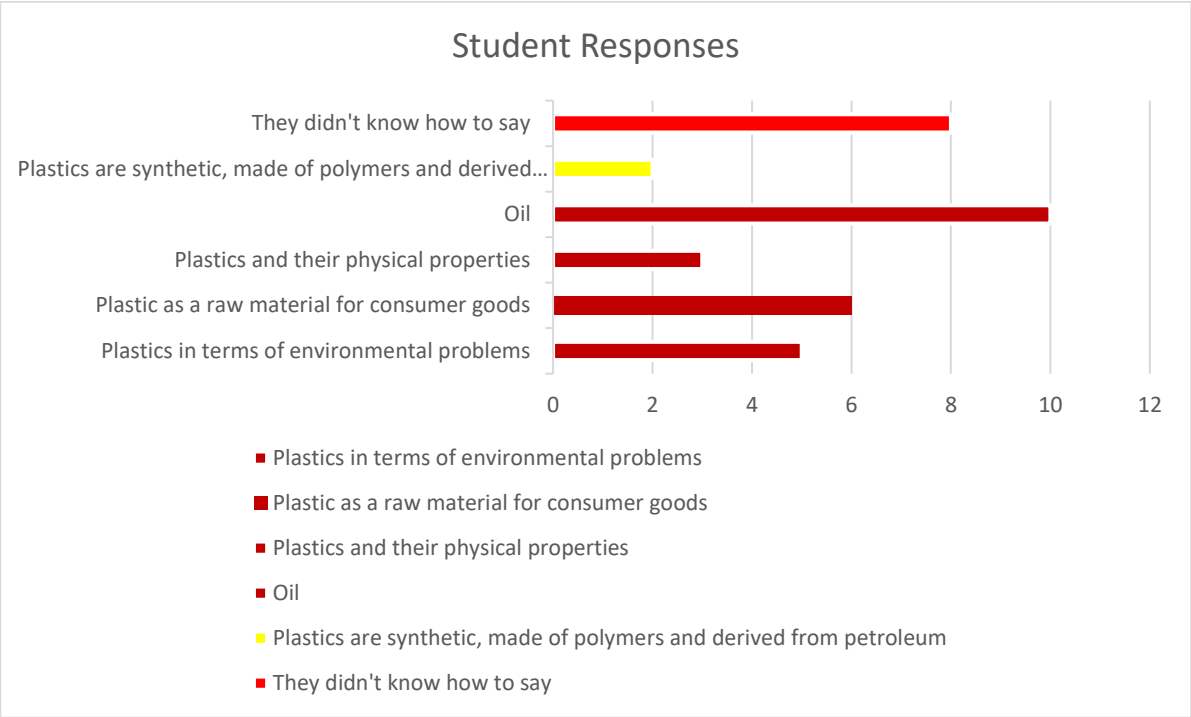
2nd question: What do you mean by plastic? What raw material is used in production?



Source: The Author (2024).

Figure 13

Student responses



Source: The Author (2024).

The results indicate that 6% of the students presented a definition close to the concept, mentioning, for example, "a material derived from petroleum widely used in everyday life". Another 71% provided incomplete or generic answers. One aspect that draws attention is the number of individuals who attribute to plastic the role of a substance used for the production of goods, such as packaging, tools and various materials, recognizing it as a raw material for the manufacture of consumer products.

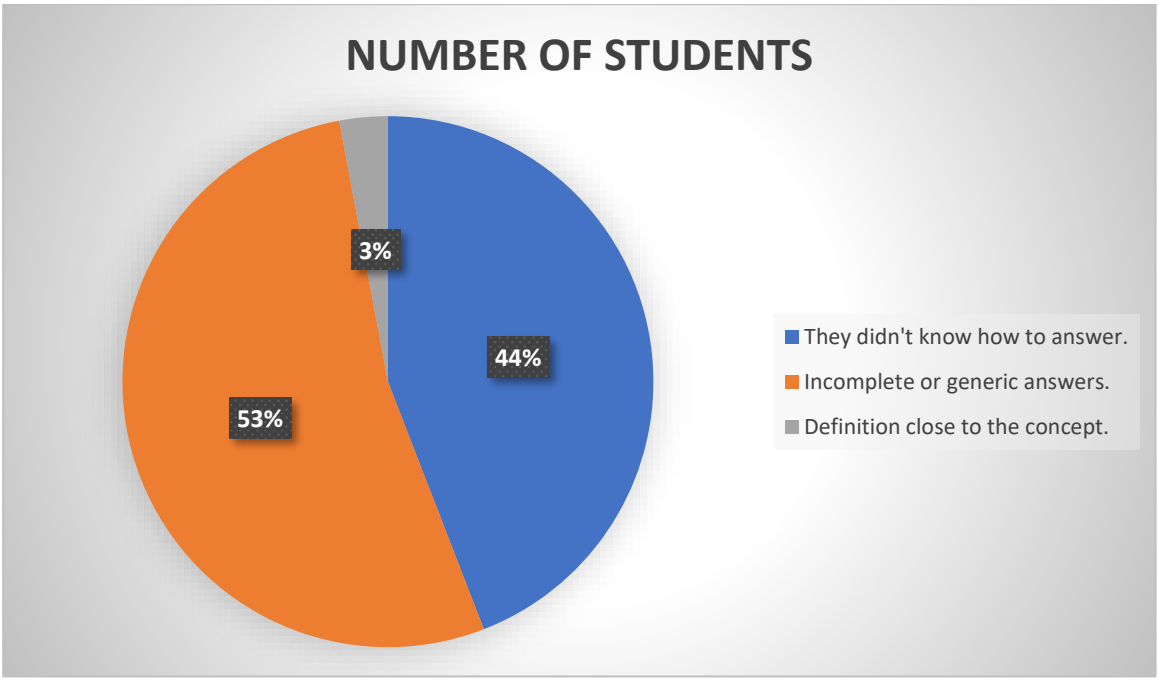
Another group of students focused on environmental aspects, bringing information such as "they are polluting", "they take time to degrade" or "they are disposed of incorrectly". In addition, one category of responses was limited to defining plastic simply as "petroleum", without any mention of processes of transformation or conversion of this raw material. Although the answers present variability and bring relevant information, it is observed that many are disconnected and without articulation, which evidences flaws in the training process. Even so, even if in a limited and disorganized way, part of the students manage to have an initial reading of the problem. In general, a large number of students recognize and attribute to oil the role of raw material for plastics, while 23% did not know how to answer the question.

This distribution reveals that, although most students have some understanding of plastic and its origin, these ideas are evidenced separately in different dimensions

(properties, composition or environmental impacts, for example). Interestingly, even though there are significant gaps that need to be worked on to deepen the understanding of the social, technological, and environmental impacts of this material, students bring to the classroom knowledge built from the world around them. This highlights the importance of pedagogical strategies that promote clearer connections between scientific concepts and students' everyday reality.

Figure 14

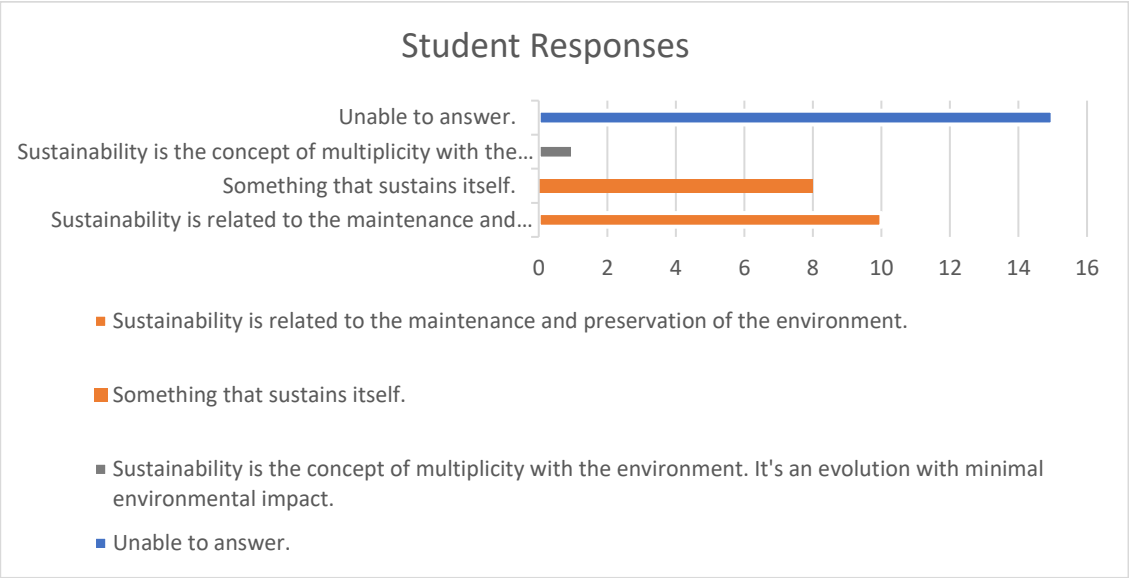
3rd question: What do you mean by sustainability?



Source: The Author (2024).

Figure 15

Student responses



Source: The Author (2024).

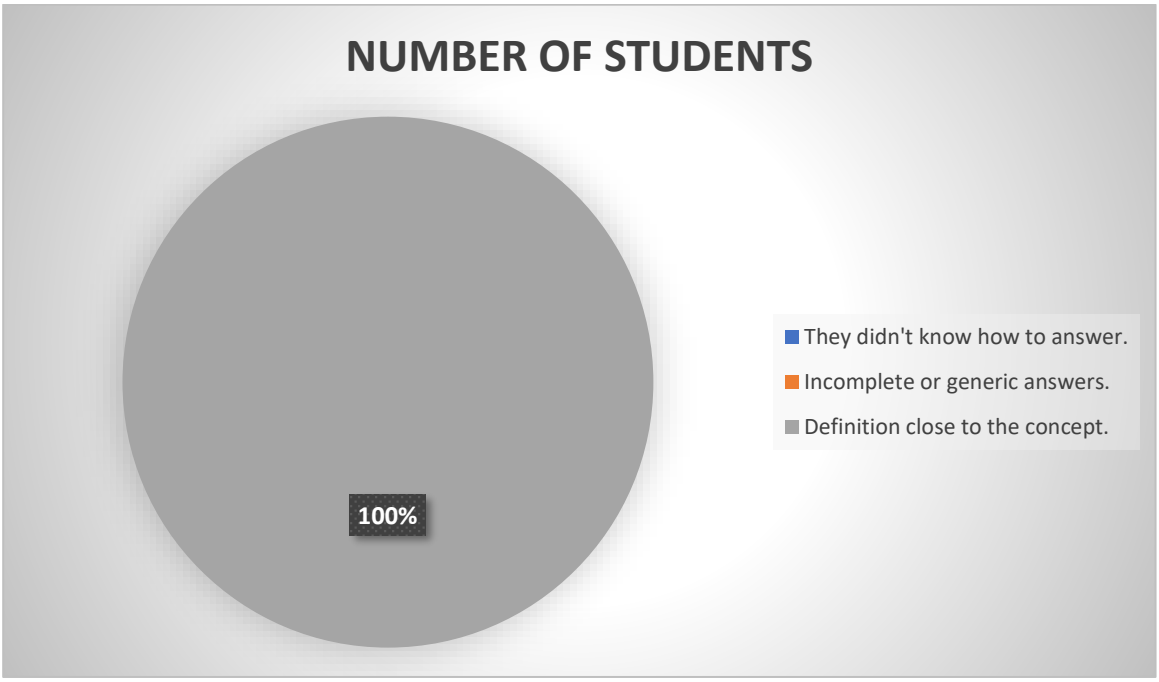
The results show that 3% of the students presented definitions close to the concept, mentioning, for example, "the responsible use of natural resources to preserve the future". The concept of sustainability was addressed by a student who cited ideas such as mutuality, evolution and impacts, demonstrating a more elaborate and sophisticated profile in relation to the others. Among the wide variety of answers, another category refers to a simpler definition, such as "something that sustains itself". Curiously, it is generally perceived that students have difficulty in verbalizing more in-depth ideas, even though there is an intuitive association of the term with its meaning. Although incomplete and superficial, these answers indicate some level of understanding.

Another 53% of the students gave incomplete or generic answers, such as "take care of the environment" or "do not pollute", while 44% did not know how to answer the question.

This pattern demonstrates that, although a significant portion has a clear notion of sustainability, there is still a large number of students who lack greater depth in understanding the topic. Working on this concept in the classroom can help develop a broader vision, relating sustainability to concrete practices, such as the use of bioplastics.

Figure 16

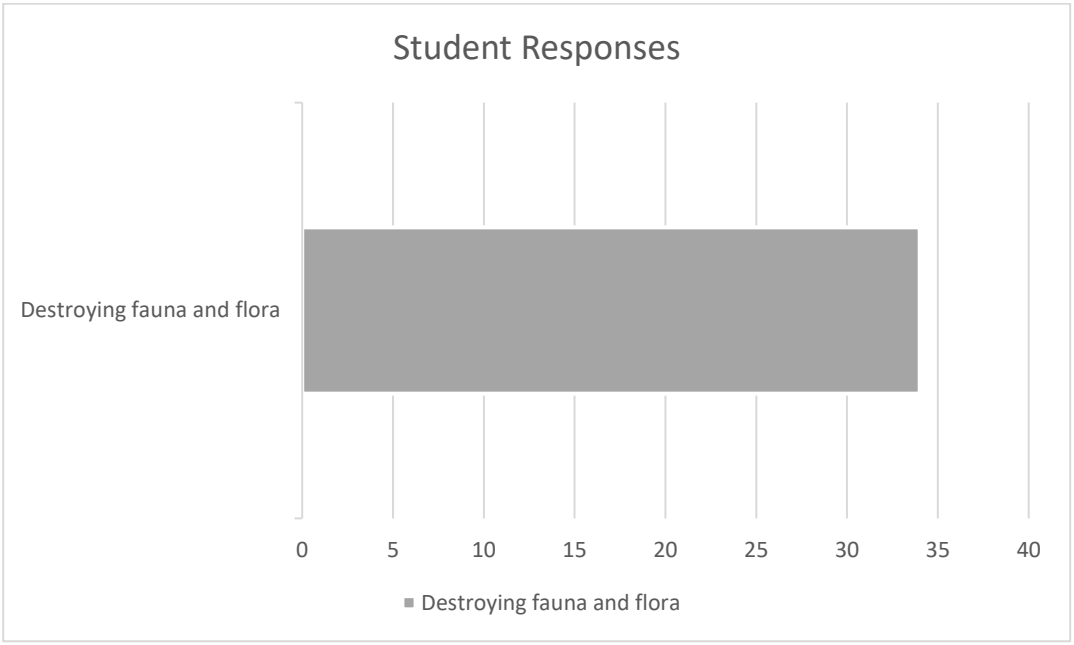
Question 4: How do you think plastics impact the environment?



Source: The Author (2024).

Figure 17

Student responses



Source: The Author (2024).

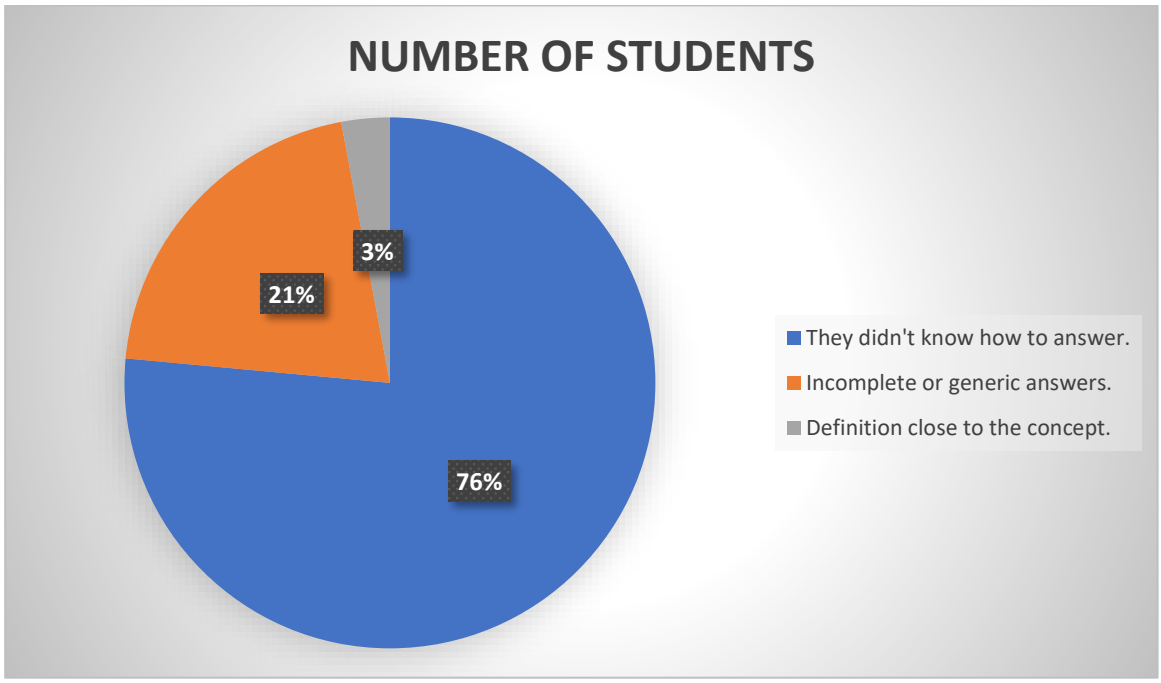
In this question, 100% of the students answered, and the results revealed a varied understanding of the environmental impacts caused by plastic. Most highlighted the "pollution of the oceans" and the "delay in decomposition", indicating a clear recognition of the most

visible problems. In addition, a significant portion mentioned the "accumulation of plastic waste in landfills" as a concern.

However, few students addressed more specific issues, such as the emission of greenhouse gases during the production of plastic or the problem of microplastics and their contamination of food chains. These results show that, although there is an initial environmental awareness, there is a need to broaden students' understanding of the less noticeable impacts of plastic

Figure 18

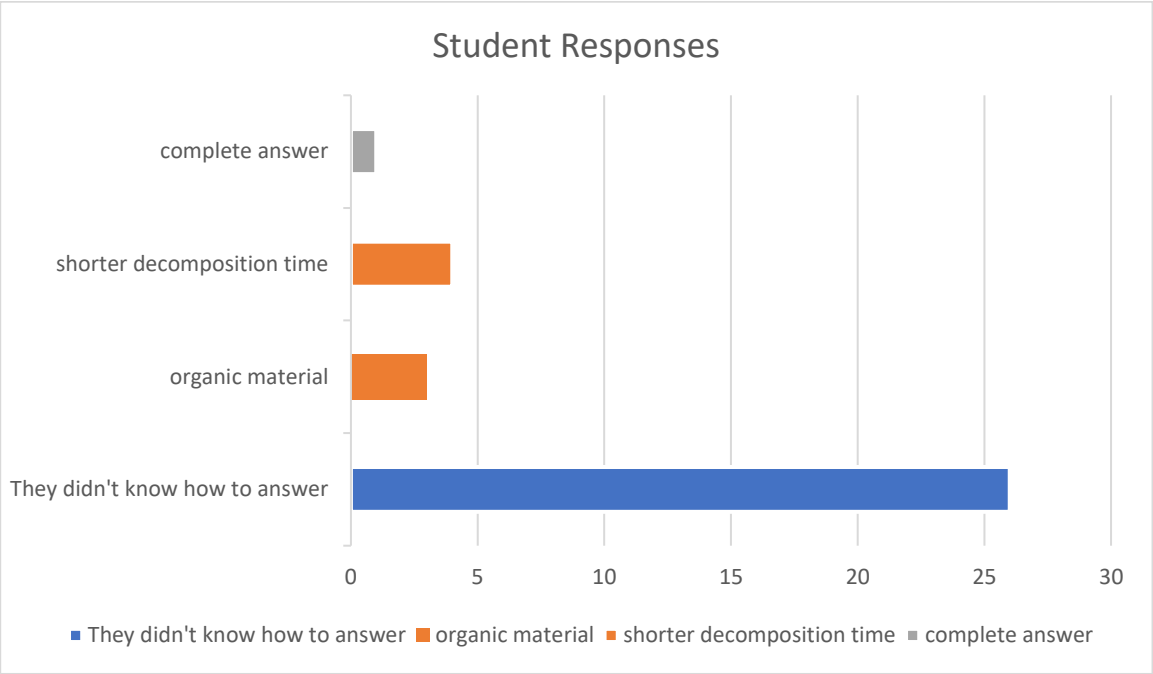
Have you ever heard of bioplastic? Explain



Source: The Author (2024).

Figure 19

Student responses



Source: The Author (2024).

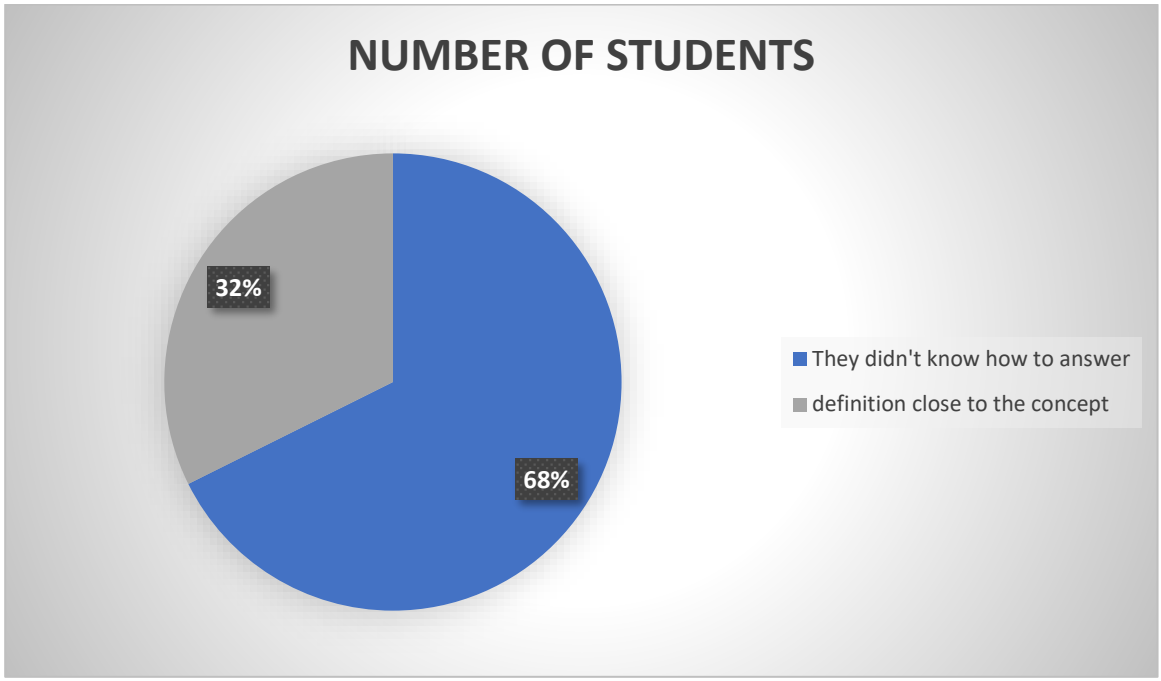
The results of this question reveal that 76% of the students did not know how to answer, demonstrating a lack of knowledge about the subject. What draws attention is that bioplastics are a relevant topic as an alternative in the production of sustainable materials, as well as their production, which can be made from simple materials (potatoes, corn starch, etc.). The introduction of these themes can help in the educational development process by looking at previous answers in which polymers or plastics are associated with petroleum. There was no significant mention of the issue of degradation. Another 21% gave incomplete or generic answers, such as "it's a different type of plastic" or "something more sustainable". Only 3% presented answers close to the concept, mentioning characteristics such as "plastic made from renewable sources, such as plants" or "plastic that decomposes faster and pollutes less". Only one of the answers took into account several aspects, such as low decomposition time, organic origin and high cost, constituting a very complete profile.

This scenario highlights a significant gap in students' knowledge about bioplastics, reinforcing the need to introduce this topic in detail in the teaching of Chemistry. The inclusion of activities that explain the composition, environmental advantages, and challenges associated with the use of bioplastics can contribute to broadening students' understanding, as well as encourage reflections on sustainable alternatives to traditional plastic.

By addressing bioplastics in the educational context, it is also possible to connect Chemistry content to practical and current issues, promoting more meaningful learning and aligned with environmental awareness.

Figure 20

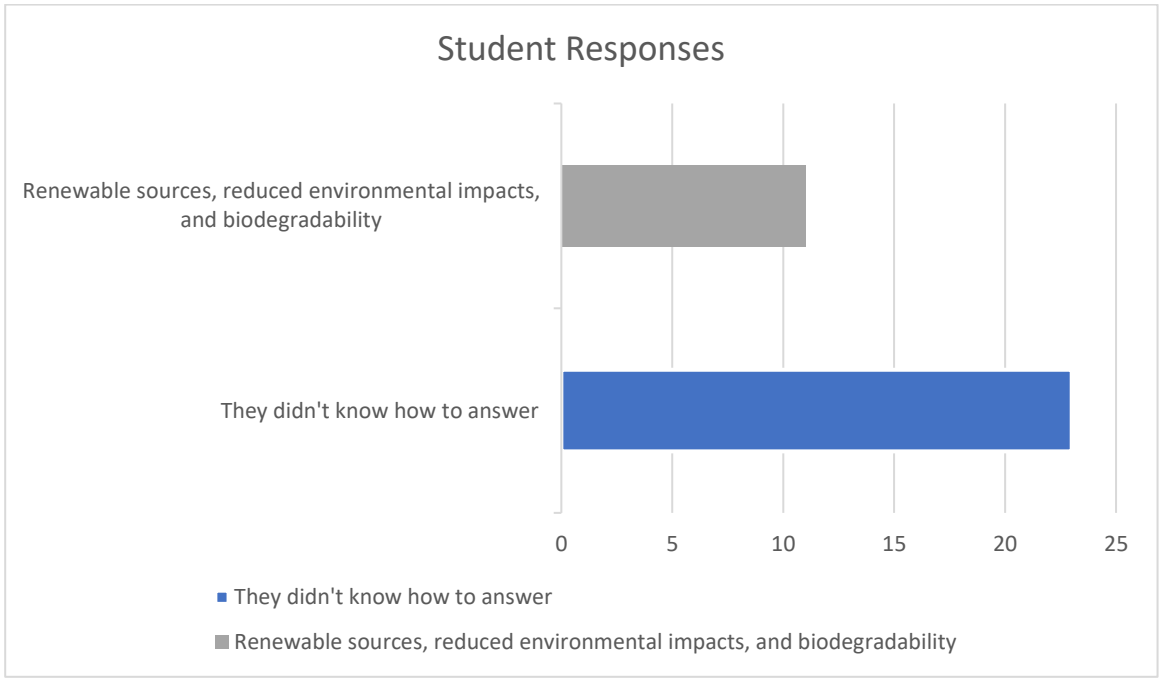
Question 6: Do you believe that the use of bioplastic is a sustainable alternative?



Source: The Author (2024).

Figure 21

Students' responses



Source: The Author (2024).

The results indicate that 68% of the students did not know how to answer this question, demonstrating a large gap in knowledge about the advantages and challenges of using bioplastics. On the other hand, 32% presented answers close to the concept, highlighting aspects such as "use of renewable sources", "reduction of environmental impacts" and "biodegradability".

This contrast between the groups highlights the need for greater debate on the sustainability of bioplastics in the educational context. While a portion of students already recognize the potential benefits, most are still unaware of the topic or are not clear about its implications. This reinforces the importance of a pedagogical approach that goes beyond basic definitions, exploring both the benefits and challenges, such as the cost of production and the technical limitations of bioplastics.

Integrating this discussion into Chemistry classes can provide students with a more critical and comprehensive view of the subject, encouraging reflections on how to balance innovation and sustainability in the use of materials

5.5 FINAL RESULTS – POST-INTERVENTION ANALYSIS

After the pedagogical intervention, the results of the final questionnaire revealed a significant advance in the students' understanding and perception of the topics addressed. The practical activities and theoretical discussions contributed to consolidate concepts that were initially little understood or unknown by most students. The analysis of the collected data shows that the combination of theoretical and practical teaching was effective in promoting learning and arousing interest in bioplastics and their relationship with sustainability.

Among the most striking points, the following stand out:

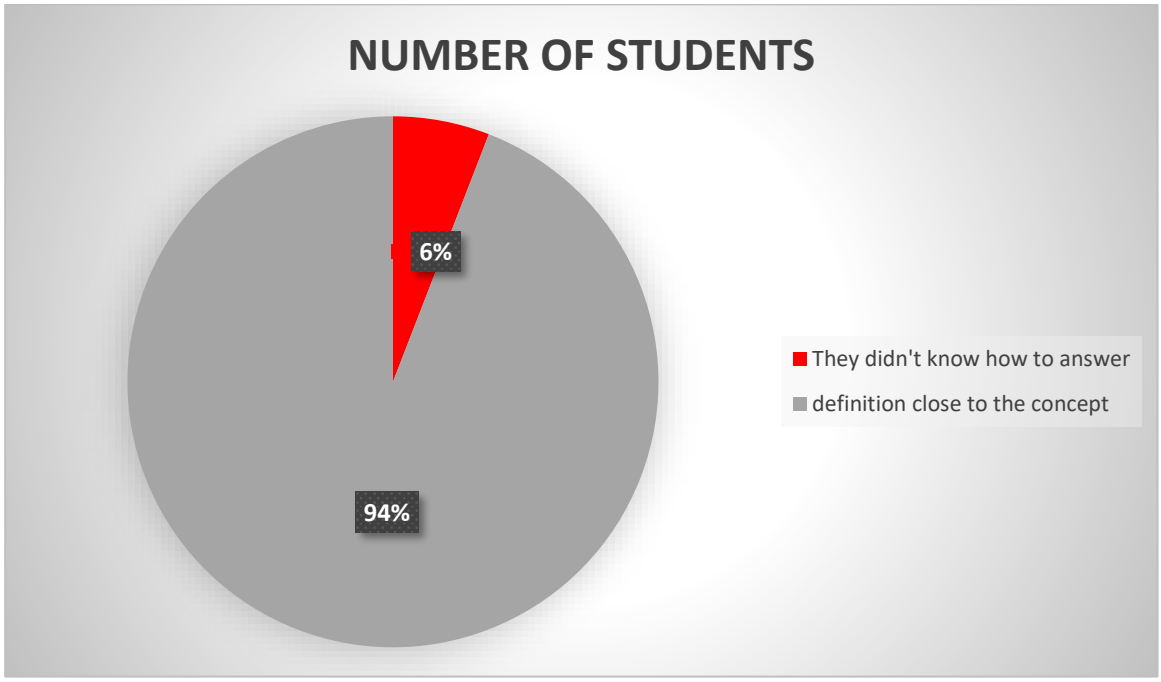
- The ability of students to develop more complete and grounded answers about the concepts of polymers, plastics and bioplastics.
- The increase in environmental awareness, reflected in discussions about the impacts of conventional plastics and the potential advantages of bioplastics.
- The appreciation of practical experience in the laboratory, pointed out as a differential for the assimilation of the contents.

The results also reinforce the importance of active pedagogical methodologies, aligned with the Science, Technology and Society (STS) movement, to integrate Chemistry content into students' daily lives, making learning more relevant and meaningful. The answers to the

questions of the final questionnaire are detailed below, presenting a deeper analysis of the progress obtained.

Figure 22

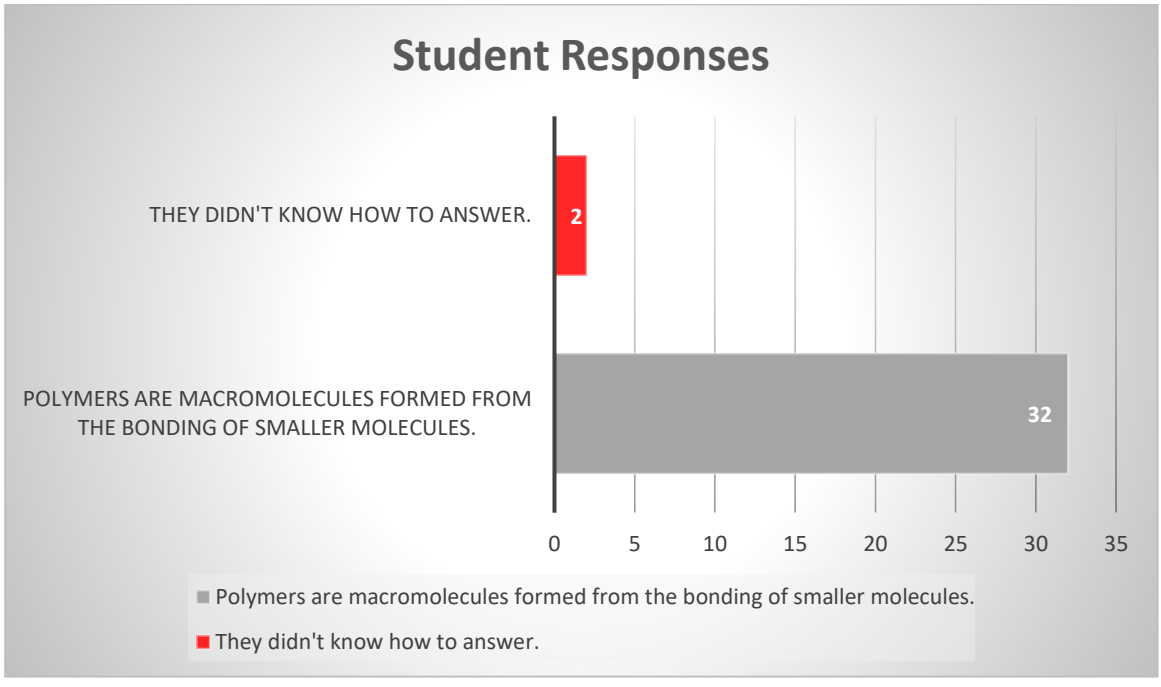
1st question: Explain in your words what you understood about polymers?



Source: The Author (2024).

Figure 23

Student responses



Source: The Author (2024).

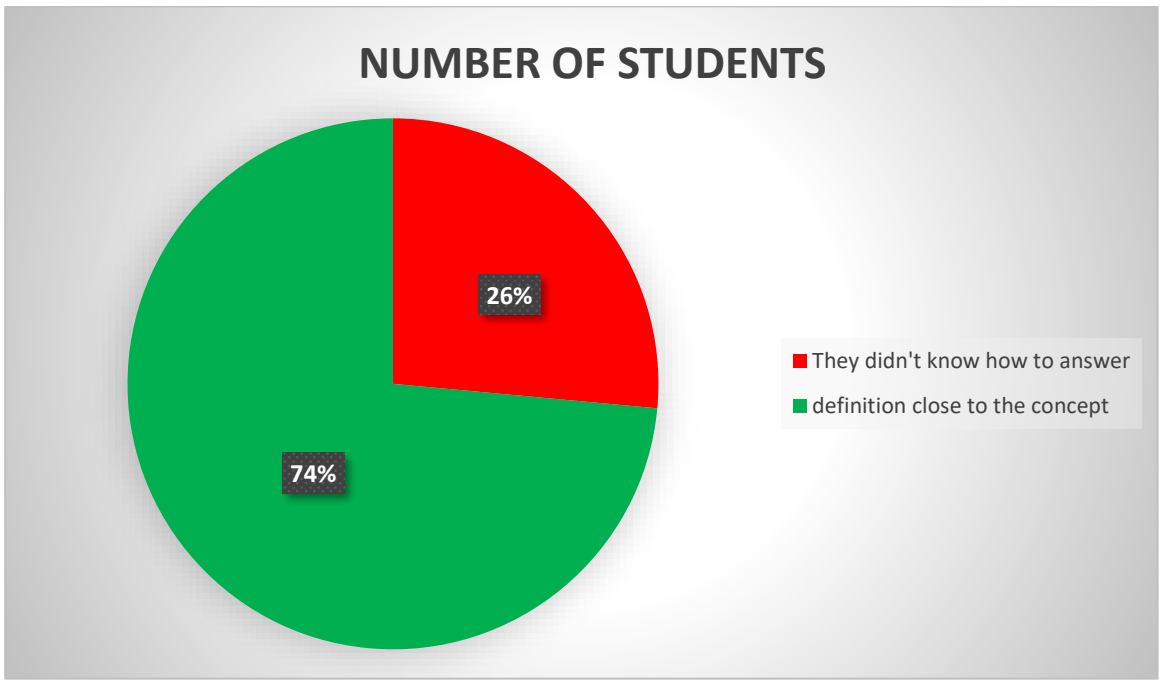
After the pedagogical intervention, the results demonstrated a significant advance in students' understanding of polymers. While in the initial stage 46% of the students did not know how to answer and 52% presented generic or incomplete answers, in the final evaluation only 2 students were unable to elaborate an answer, and 34 students presented clear and consistent definitions on the theme.

These results reflect the effectiveness of the teaching strategies adopted, such as the use of practical examples, experiments and guided discussions, which facilitated the assimilation of the concept of polymers. Answers such as "polymers are long chains of molecules formed by repetitive units" and "materials such as plastics and rubbers made from chemical reactions" were recurrent, evidencing the internalization of theoretical concepts.

This progress highlights the importance of didactic interventions that connect Chemistry content to applied and everyday contexts, as Krasilchik (2004) suggests, when emphasizing that teaching should promote the understanding of scientific phenomena in a meaningful way. In addition, the practical and interdisciplinary approach, aligned with the Science, Technology and Society (STS) movement, has proven to be a powerful tool to engage students and consolidate learning.

Figure 24

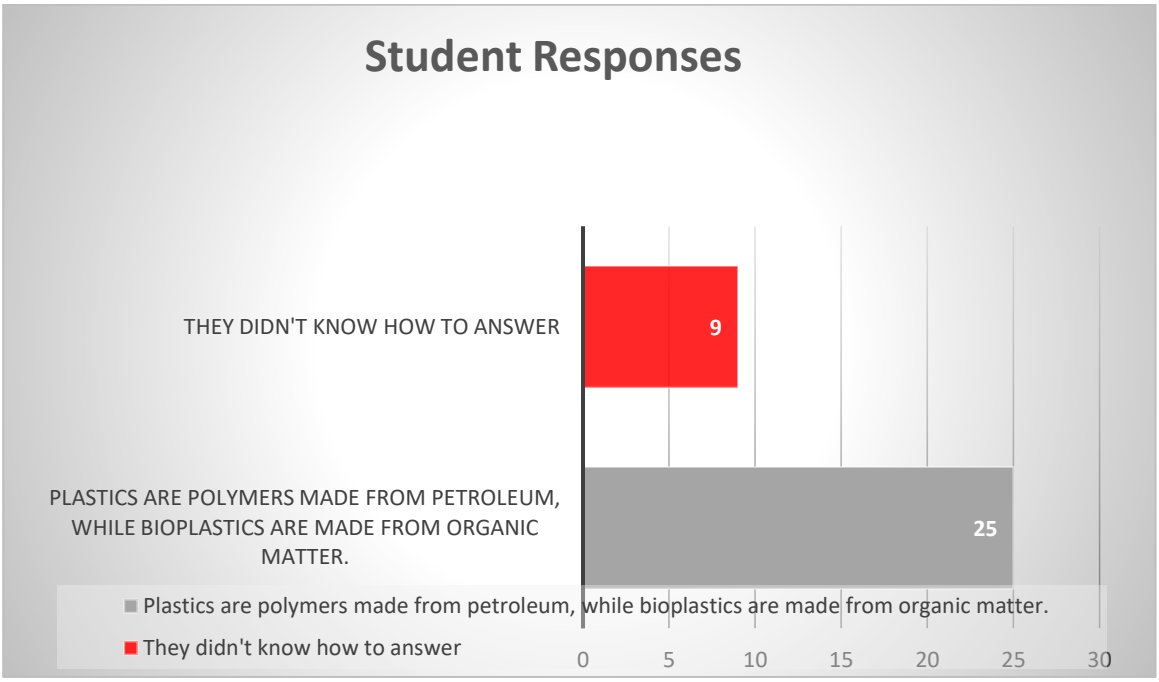
Question 2: Explain what plastics and bioplastics are



Source: The Author (2024).

Figure 25

Student responses



Source: The Author (2024).

The results of this question demonstrated a significant evolution in the students' understanding after the intervention. While in the initial survey most students had conceptual gaps, now 74% have been able to develop adequate answers, correctly explaining what plastics and bioplastics are, while 26% still had difficulties in answering.

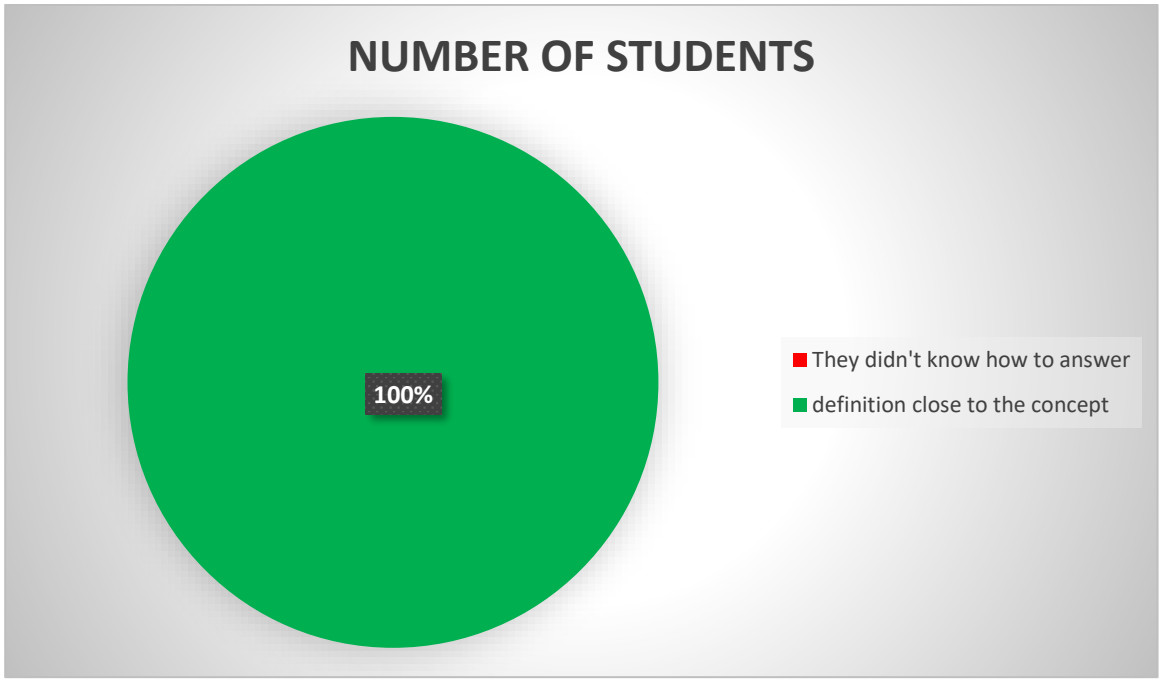
Students who responded appropriately described plastics as petroleum-derived polymers and identified bioplastics as materials that come from organic sources, such as sugarcane, starch. Some responses went further, highlighting characteristics such as "biodegradable" or "shorter decomposition time", showing an advance in understanding the environmental impacts of both materials.

This progress reflects the effectiveness of the didactic activities implemented, which emphasized both the concept and the practical applications of plastics and bioplastics. As Krasilchik (2004) points out, the connection between theoretical knowledge and the students' daily lives is essential to consolidate learning. In addition, the practical approach made it possible to discuss current issues, such as sustainability and waste reduction, in line with the guidelines of the Science, Technology and Society (STS) movement.

On the other hand, the 26% who have not yet been able to respond suggest that it is necessary to strengthen teaching strategies to reach all students more effectively. This could include more interactive activities, such as experiments or group discussions, that facilitate the internalization of concepts.

Figure 26

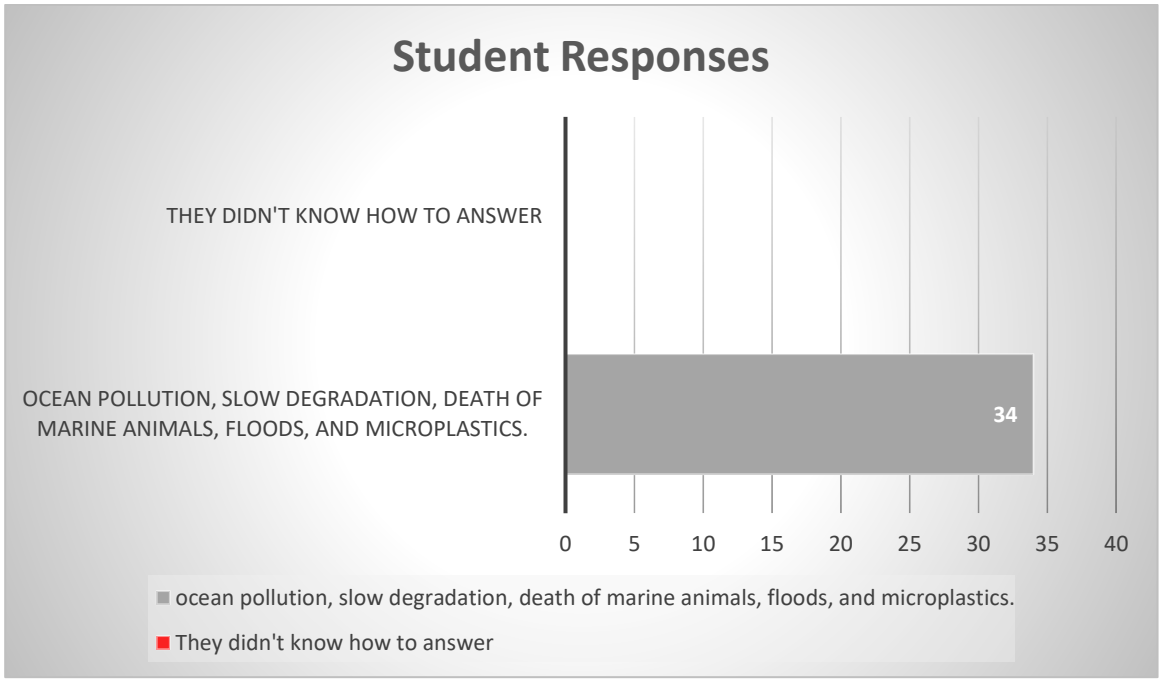
Question 3: What are the main environmental impacts caused by plastics?



Source: The Author (2024).

Figure 27

Student responses



Source: The Author (2024).

The results of this question demonstrate a significant evolution in the students' understanding after the pedagogical intervention. All 34 students were able to respond,

showing an advance in the perception of environmental impacts related to plastics. The responses highlighted critical problems, such as "pollution of the seas", "delay in degradation", "death of marine animals", "floods caused by the accumulation of plastic waste" and "damage to fauna and flora".

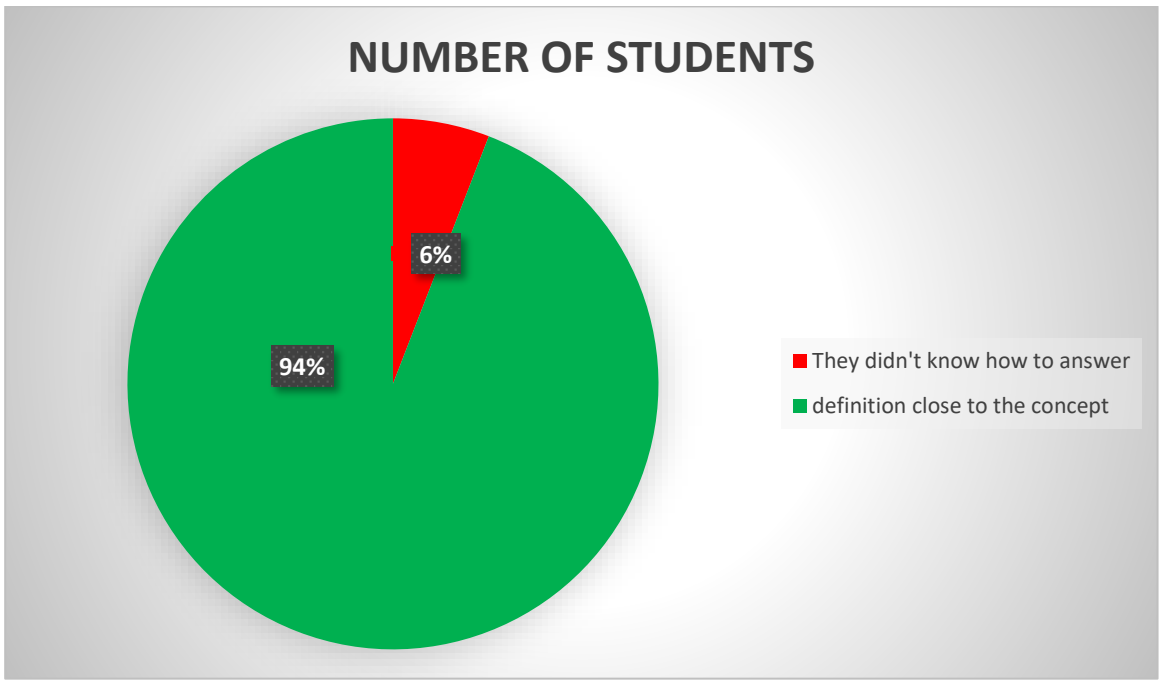
This result reinforces the effectiveness of the activities developed, which allowed students to understand not only the visible impacts of plastic on the environment, but also the less noticeable effects, such as the contamination of the food chain by microplastics. Prior to the intervention, many students had a superficial knowledge of these impacts; now, they demonstrate a deeper and more critical understanding of the environmental problem.

The approach used, based on the Science, Technology and Society (STS) movement, contributed to the students connecting scientific knowledge to concrete environmental challenges. As highlighted by Krasilchik (2004), integrating science and everyday reality strengthens learning and makes students more prepared to reflect on sustainable solutions.

This new perception of students about the environmental impacts of plastic highlights the relevance of discussing alternatives such as bioplastics and the need for effective public policies to reduce the consumption and improper disposal of these materials.

Figure 28

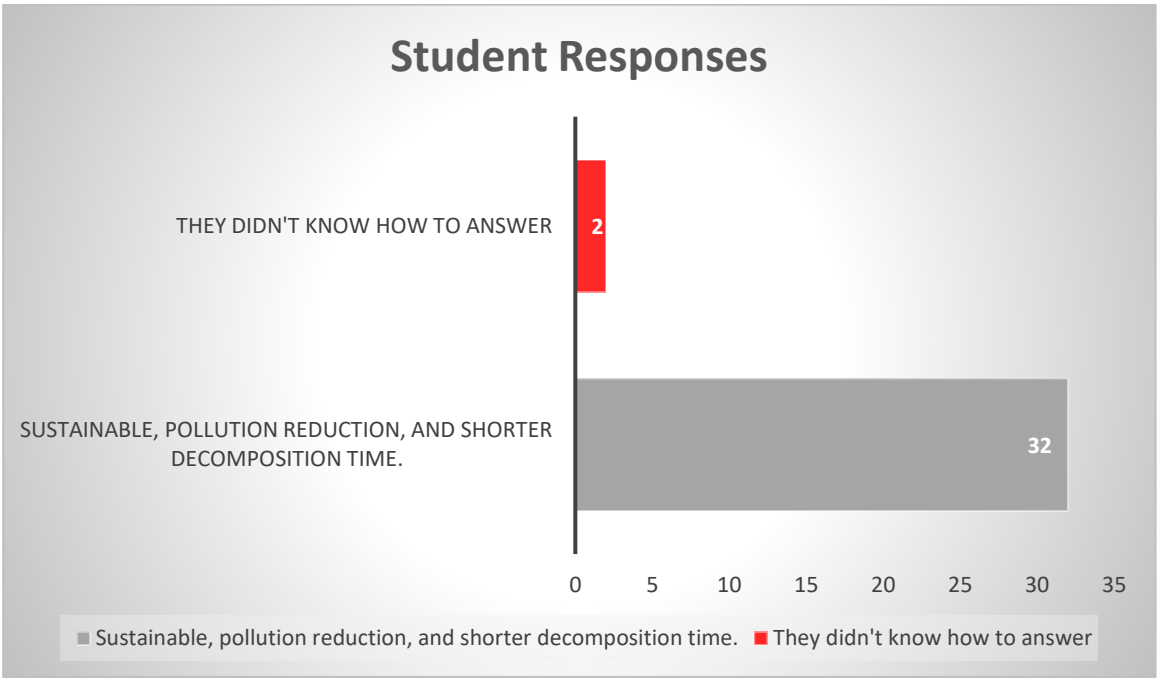
Question 4: How can bioplastics reduce these impacts?



Source: The Author (2024).

Figure 29

Student responses



Source: The Author (2024).

The results of this question indicated a remarkable advance in the students' understanding after the pedagogical intervention. Of the 34 participants, 94% were able to respond adequately, associating bioplastics with characteristics such as "shorter decomposition time", "more sustainable" and "less polluting". Only 6% (2 students) did not know how to answer, evidencing a significant reduction in the knowledge gaps observed in the initial stage.

Compared to the initial questionnaire, in which a large part of the students demonstrated ignorance about bioplastics, these results reflect the effectiveness of the educational activities implemented. The hands-on approach and guided discussions on the environmental impact of traditional materials versus bioplastics provided students with a clearer understanding of the environmental advantages of these alternative polymers.

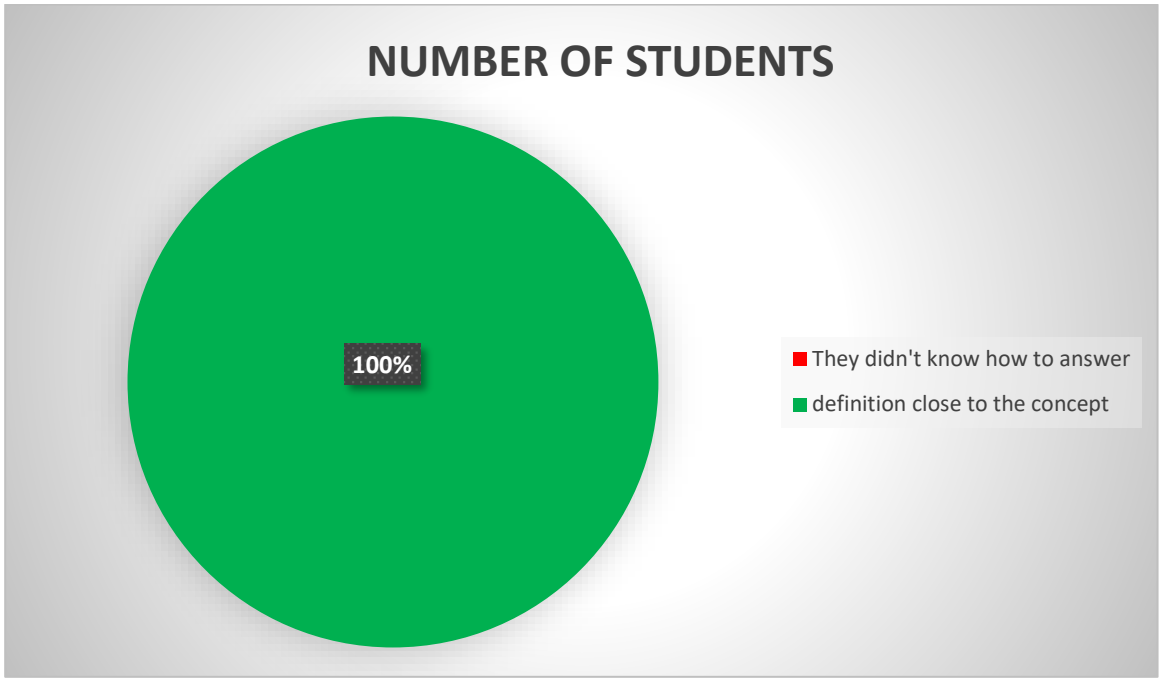
In addition, the students came to recognize the relevance of the use of bioplastics in combating plastic waste problems, such as "ocean pollution" and "accumulation in landfills", mentioned in the previous step. This evolution reinforces the importance of active methodologies in the teaching of Chemistry, which connect scientific content to current environmental issues, promoting critical thinking and awareness.

As highlighted by Krasilchik (2004) and in the Science, Technology and Society (STS) movement, integrating socio-environmental issues into teaching is essential to form more aware and engaged citizens. Students' understanding of bioplastics and their contribution to

sustainability demonstrates the positive impact of a contextualized and practical pedagogical approach.

Figure 30

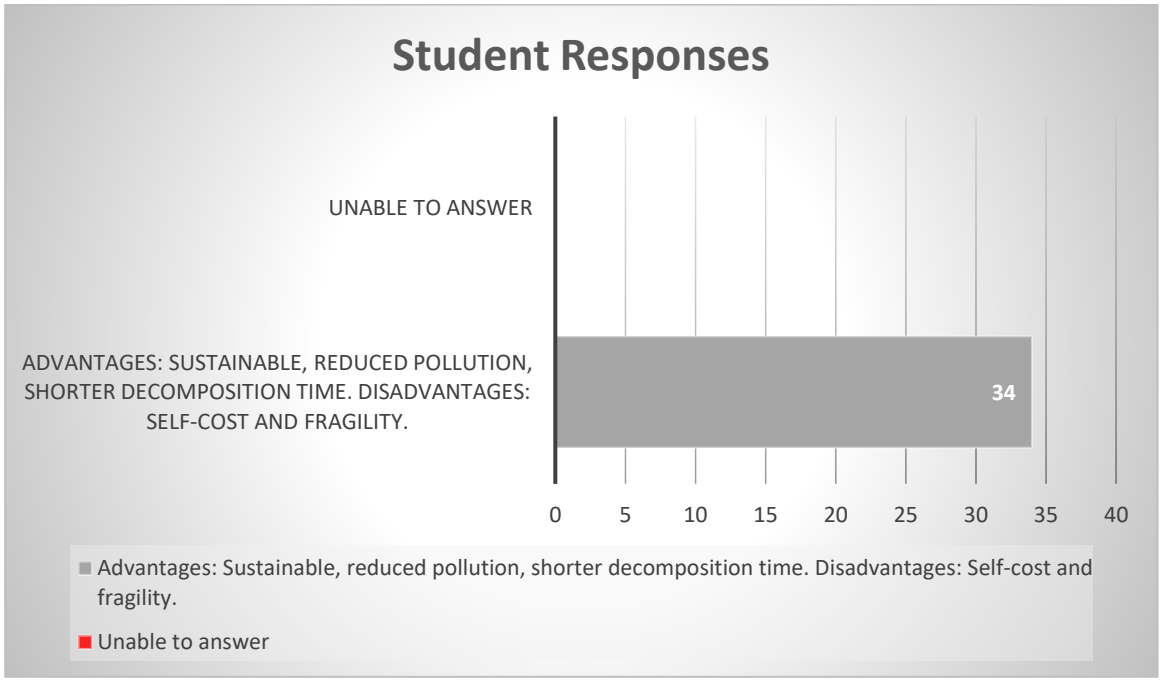
5th question: In your opinion, what are the biggest advantages and disadvantages of bioplastics?



Source: The Author (2024).

Figure 31

Student responses



Source: The Author (2024).

In this question, 100% of the students participated, which in itself already demonstrates a greater engagement in relation to the previous stages. Among the most cited advantages, the "reduction of pollution", the "shorter decomposition time" and the fact that they are "more sustainable" stood out. These points indicate that the students were able to relate the use of bioplastics as a viable alternative to minimize the environmental impacts caused by conventional plastics.

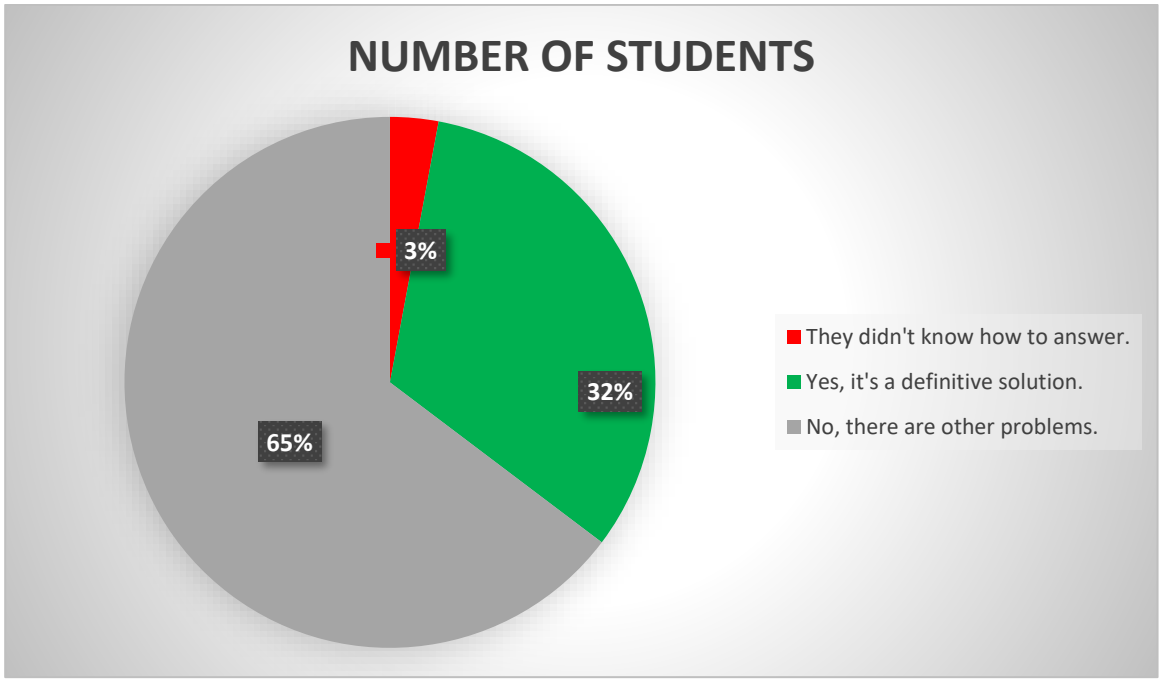
On the other hand, when reflecting on the disadvantages, the students mentioned "high production cost", "fragility of the material" and, to a lesser extent, the "difficulty of completely replacing traditional plastics in some applications". This recognition demonstrates that, in addition to understanding the benefits, students also began to take a critical view of the challenges associated with the use of bioplastics.

This progress shows the positive impact of the pedagogical intervention, since, in the initial survey, most students had vague answers or were even unaware of the theme. The methodology adopted, which included practical discussions and activities based on the Science, Technology and Society (STS) movement, helped students to reflect not only on the theoretical concepts, but also on the socioeconomic and technological aspects of the use of bioplastics.

As Krasilchik (2004) suggests, bringing teaching closer to everyday topics increases the relevance of learning and promotes a more contextualized education. In addition, the discussion on bioplastics provided a valuable opportunity for students to analyze technological choices in the light of sustainability, an essential aspect for the formation of critical and conscious citizens.

Figure 32

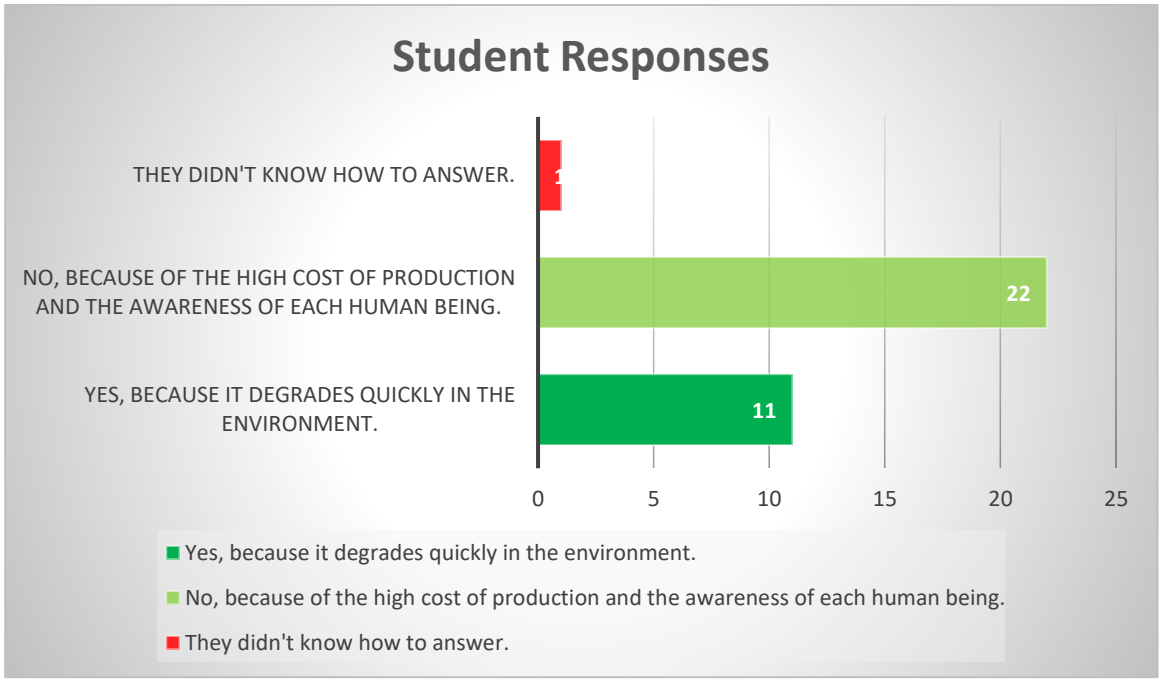
Question 6: Do you think bioplastics are a definitive solution to the environmental problems caused by plastics? Why?



Source: The Author (2024).

Figure 33

Student responses



Source: The Author (2024).

The results of this question showed a total participation of the students, with 100% responding. Among them, 22 (65%) stated that bioplastics are not a definitive solution to

environmental problems, while 11 (32%) believe that they can be a solution. Only 1 student (3%) stated that he did not know how to answer.

The students who pointed out that bioplastics are not a definitive solution justified their answers with relevant arguments, such as "the high cost", "the need for individual awareness" and "the difficulty of completely replacing traditional plastics". These responses reflect a more mature and critical view of the challenges faced in the broad adoption of this material. On the other hand, the 32% who considered bioplastics a definitive solution emphasized benefits such as "reduced pollution" and "biodegradability", showing that they understand the positive aspects of this material.

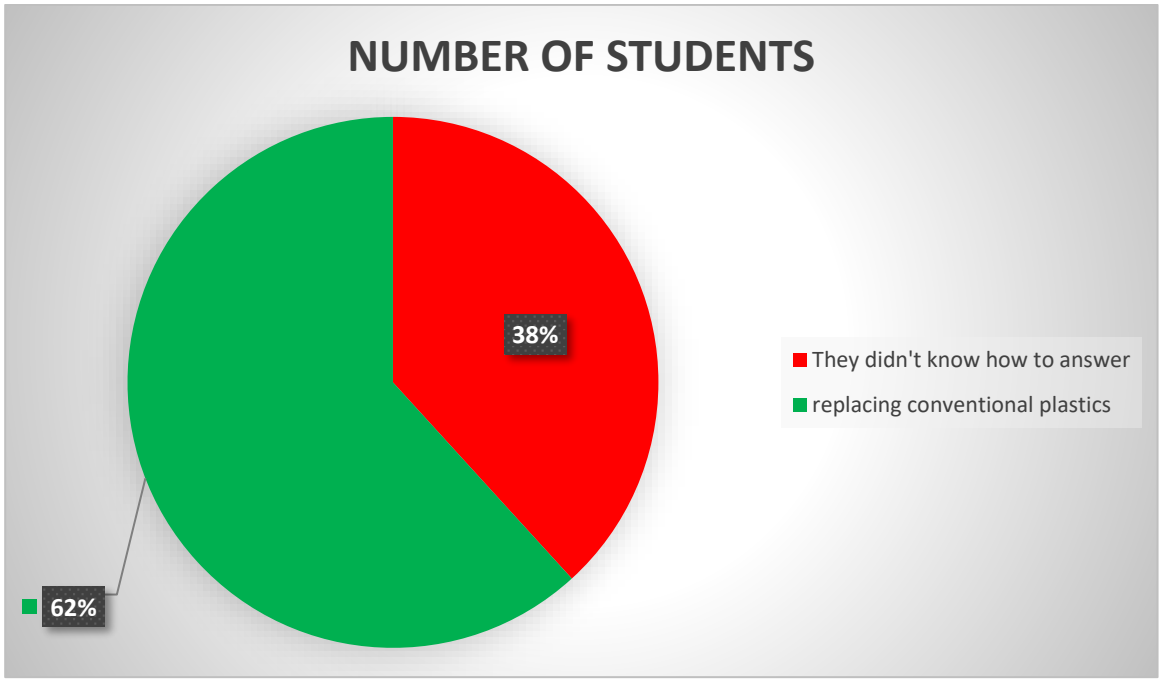
Comparing these results with the initial survey, an evolution in the students' level of reflection can be perceived. Initially, many had a superficial understanding or were unaware of the topic, while now they demonstrate a more balanced analysis, considering both the benefits and limitations of bioplastics.

This discussion highlights the effectiveness of the pedagogical approach adopted, which included debates, practical activities and the contextualization of Chemistry contents with real environmental problems. As defended by Krasilchik (2004), integrating the teaching of science into the daily lives of students is essential to promote critical thinking and the formation of conscious citizens. In addition, the alignment with the Science, Technology and Society (STS) movement enabled students to analyze the socioeconomic and environmental implications of technological solutions.

The students' perception that bioplastics are not a definitive solution highlights the importance of adopting integrated strategies to address environmental problems, such as public policies, technological innovation, and behavioral changes. This critical reflection is essential for a broader and more grounded understanding of environmental issues, preparing students to contribute to sustainable solutions in the future.

Figure 34

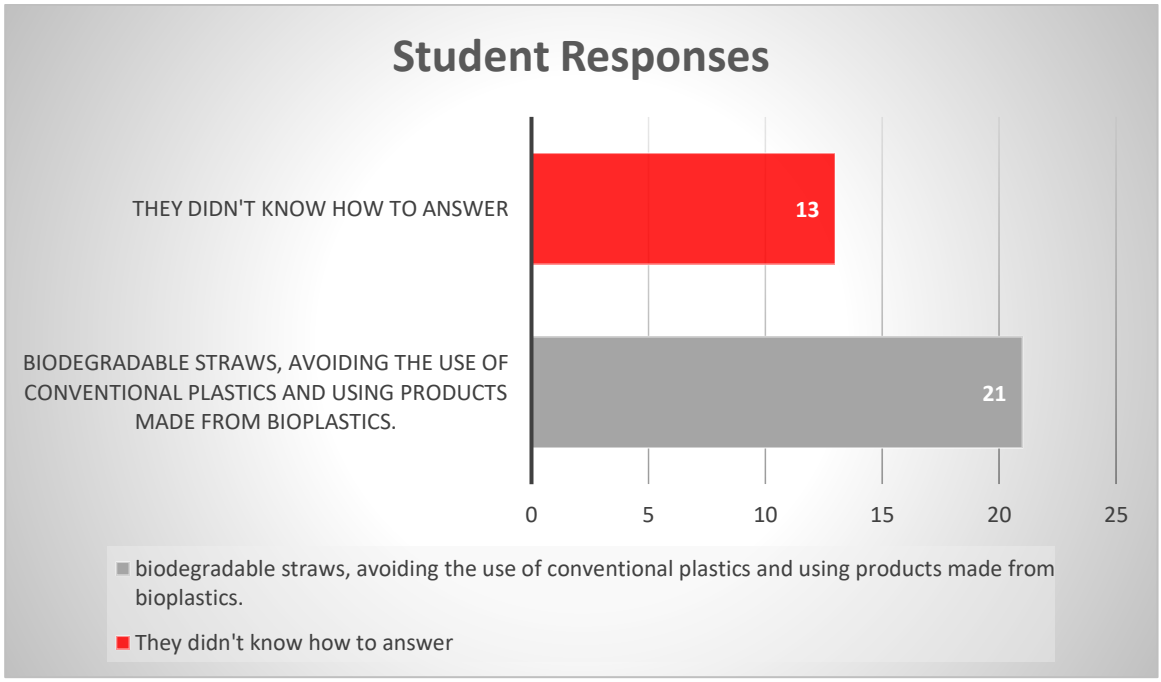
Question 7: Give an example of how you would apply knowledge about bioplastics in your daily life



Source: The Author (2024).

Figure 35

Student responses



Source: The Author (2024).

The results of this question revealed a significant level of participation, with 100% of students responding. Among them, 21 (62%) indicated that they would use bioplastics in

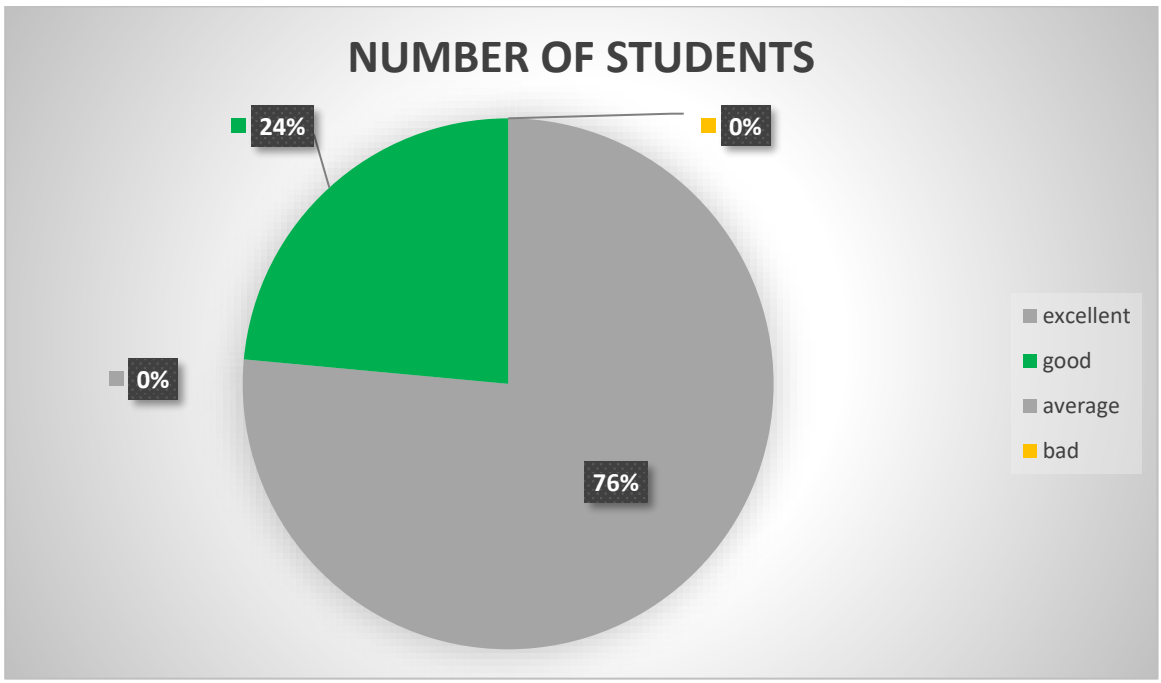
items such as "straws", "disposable objects" and other everyday products, demonstrating a practical understanding of how to integrate bioplastics into their routines. On the other hand, 13 students (38%) were unable to present concrete examples, showing that there is still room to reinforce the practical application of the knowledge acquired.

The predominance of answers focused on simple everyday objects reflects an initial perception of students about the usefulness of bioplastics, indicating that the pedagogical intervention was able to bring clarity about the applicability of this material in practical situations. However, the remaining gaps suggest the need to broaden the debate in the classroom, encouraging students to think about more diverse and more impactful applications, such as in the agricultural sector, industry, and sustainable packaging for the food market.

These results reinforce the importance of a pedagogical approach that connects the contents of Chemistry to concrete and current issues. As Krasilchik (2004) points out, integrating scientific knowledge into students' daily lives is essential to promote meaningful learning and prepare students to face environmental and social challenges in a practical and critical way.

Figure 36

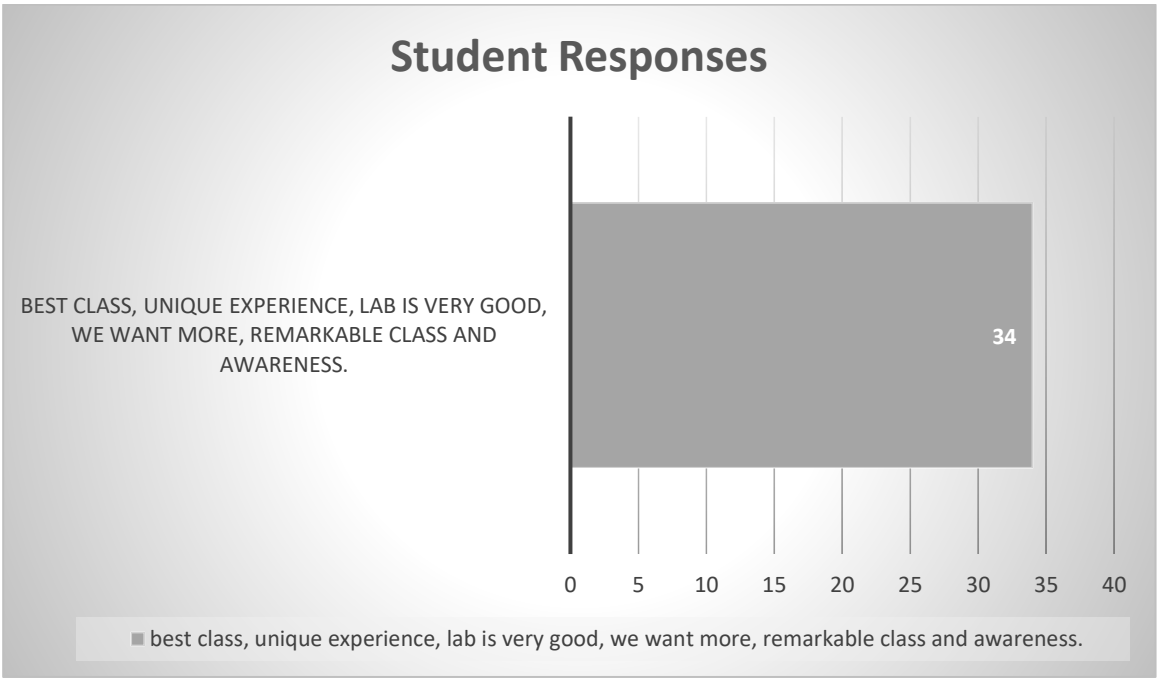
8th question: What is your assessment of the class?



Source: The Author (2024).

Figure 37

Student responses



Source: The Author (2024).

The results of this question were extremely positive and demonstrated the significant impact of the pedagogical intervention. All students participated, and the reports showed both the engagement and the relevance of the practice for the understanding of the contents covered. Comments such as "helps raise awareness," "lab experience," and "beneficial" highlighted how students valued the opportunity to work with bioplastics in a practical and contextualized way.

Many highlighted that they learned about important topics, such as "the importance of reducing pollution" and "the benefits of bioplastics". A striking report was that the class was "one of the coolest two hours I've ever had", reinforcing that the methodology adopted managed to unite fun and learning efficiently. In addition, the students showed enthusiasm for the class format, suggesting that the experience positively marked their perception of the teaching of Chemistry.

Another highlight was the practice carried out with simple and accessible everyday materials, which brought students closer to reality and facilitated the understanding of complex concepts, such as biodegradability and sustainability. This hands-on approach was essential in transforming theoretical learning into something tangible and relevant to students' lives.

These results corroborate what Krasilchik (2004) points out about the importance of connecting teaching to students' experiences, providing a more meaningful education. In

addition, the methodology adopted is aligned with the Science, Technology and Society (CTS) movement, emphasizing the formation of critical and conscious citizens, prepared to face current socio-environmental challenges.

The class demonstrated that well-structured pedagogical practices can not only transmit scientific knowledge, but also inspire and engage students, reinforcing the connection between science, society, and sustainability.

5 FINAL CONSIDERATIONS

The main objective of this study was to promote environmental awareness among high school students, through a didactic sequence focused on the exploration of bioplastics as a sustainable alternative to conventional synthetic polymers. The proposed approach integrated scientific concepts into the students' reality, encouraging critical reflection on the environmental impacts of the use of plastics and the need for more sustainable technological solutions.

The results showed that the didactic sequence adopted was effective in expanding the students' understanding of polymers, plastics and bioplastics. The experimental activity of bioplastic synthesis from corn starch stood out as an essential pedagogical resource to consolidate theoretical learning and arouse students' interest in Chemistry applied to sustainability. It was observed that most students were able to establish relationships between the use of bioplastics and the reduction of environmental impacts, emphasizing aspects such as biodegradability, renewable origin of the raw material and potential to minimize plastic pollution.

However, some difficulties were identified. It was noted that some students had difficulties in associating the chemical concepts addressed in the theory with practical applications, demonstrating the need to reinforce the relationship between scientific principles and their applicability in everyday life. In addition, the lack of engagement of some students during the activities suggests the need to improve pedagogical strategies to contemplate different learning profiles and expand the active participation of students.

The practical experience in the laboratory highlighted the relevance of active methodologies in the teaching of Chemistry, showing how the connection between theory and practice favors the assimilation of scientific concepts and the development of a critical and contextualized view. The insertion of the theme in high school, aligned with the Science, Technology and Society (STS) movement, proved to be a promising approach to make the teaching of Chemistry more dynamic, meaningful and closer to the reality of students.

For future research, it is recommended to expand the study to different classes and levels of education, in order to evaluate the effectiveness of the didactic sequence in different contexts. In addition, it would be pertinent to explore new sources of raw material for the production of bioplastics, such as agro-industrial waste, as well as to discuss in greater depth the technical and economic challenges related to their large-scale production. Another possibility would be the expansion of studies on polymers, including a comparative analysis between different types of synthetic and natural polymers, their physicochemical properties and their technological applications in sectors such as biomaterials, smart packaging and conductive polymers.

In this way, this work reinforces the importance of innovative pedagogical approaches that relate the teaching of Chemistry to contemporary themes, promoting the development of critical and conscious citizens. The scientific training of students must go beyond the simple transmission of knowledge, stimulating their ability to apply the concepts acquired in an ethical and sustainable way, contributing to the technological and environmental advancement of society.

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"Teaching is not just a good deed; it is a blessed task that leaves indelible marks." —St. Josemaría Escrivá, Furrow 229

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exchanges of knowledge, for the mutual support and for the shared challenges, which have immensely enriched this trajectory.

Finally, I address my gratitude to the future readers of this work, in the hope that these pages can foster reflections, inspire new discoveries and contribute to the construction of a more sustainable and humanized education.

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