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GENETICALLY MODIFIED FOOD: A SCIENTIFIC AND SOCIAL APPROACH IN A PUBLIC SCHOOL IN THE AGRESTE REGION OF PERNAMBUCO

ALIMENTOS TRANSGÊNICOS: UMA ABORDAGEM CIENTÍFICA E SOCIAL EM UMA ESCOLA PÚBLICA NO AGRESTE PERNAMBUCANO

ALIMENTOS TRANSGÉNICOS: UN ENFOQUE CIENTÍFICO Y SOCIAL EN UNA ESCUELA PÚBLICA DE LA REGIÓN AGRESTE DE PERNAMBUCO

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ABSTRACT

This article presents a pedagogical proposal on genetically modified foods, highlighting the importance of addressing the topic in the school environment to promote scientific literacy and critical thinking. Through a lesson structured in stages: diagnostic, expository, and playful, we sought to assess and expand students' knowledge about Genetically Modified Organisms (GMOs), their benefits, risks, and social and environmental implications. The results showed significant progress in students' understanding after the intervention, with a significant increase in average scores and greater participation in discussions. Based on authors such as FAO (2017), Paine et al. (2005), and Schurman & Munro (2010), among others, the study shows that interactive and contextualized methodologies are effective in filling conceptual gaps and training citizens to be more aware and prepared to participate in debates on food security and biotechnology. The initial diagnostic assessment revealed an overall average of only 23.6% correct answers, highlighting weaknesses in understanding the topic. Specific questions such as definition, purpose, and examples of GMOs obtained low correct answer rates, ranging from 15% to 32%. After implementing the pedagogical proposal, students showed significant improvement, achieving an average score of 4.2 out of 5 in the final assessment. In the playful stage, 89% of the class actively participated in the activity, and 43% of the students achieved superior performance, with correct answers above 80% of the concepts discussed orally. These data reinforce the positive impact of teaching

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strategies that prioritize student leadership and the contextualization of scientific content with current and socially relevant topics.

Keyword: Genetically Modified Foods. Genetically Modified Organisms (GMOs). Biotechnology.

RESUMO

Este artigo apresenta uma proposta pedagógica sobre alimentos transgênicos, destacando a importância de abordar o tema no ambiente escolar para promover o letramento científico e o pensamento crítico. Por meio de uma aula estruturada em etapas: diagnóstica, expositiva e lúdica, buscou-se avaliar e ampliar o conhecimento dos alunos sobre Organismos Geneticamente Modificados (OGMs), seus benefícios, riscos e implicações sociais e ambientais. Os resultados demonstraram um progresso significativo na compreensão dos estudantes após a intervenção, com aumento expressivo nas médias de acerto e maior participação nas discussões. Fundamentado em autores como FAO (2017), Paine et al. (2005) e Schurman & Munro (2010), entre outros, o estudo evidencia que metodologias interativas e contextualizadas são eficazes para suprir lacunas conceituais e formar cidadãos mais conscientes e preparados para participar dos debates sobre segurança alimentar e biotecnologia. A avaliação diagnóstica inicial revelou uma média geral de apenas 23,6% de acertos, evidenciando fragilidades no entendimento sobre o tema. Questões específicas como definição, finalidade e exemplos de transgênicos obtiveram índices baixos de acertos, variando entre 15% e 32%. Após a aplicação da proposta pedagógica, os alunos demonstraram melhora significativa, alcançando média de 4,2 pontos em 5 possíveis na avaliação final. Na etapa lúdica, 89% da turma participou ativamente da atividade, e 43% dos estudantes alcançaram desempenho superior, com acertos acima de 80% dos conceitos discutidos oralmente. Esses dados reforçam o impacto positivo de estratégias didáticas que priorizam o protagonismo estudantil e a contextualização do conteúdo científico com temas atuais e socialmente relevantes.

Palavras-chave: Alimentos Transgênicos. Organismos Geneticamente Modificados (OGMs). Biotecnologia.

RESUMEN

Este artículo presenta una propuesta pedagógica sobre los alimentos transgénicos, destacando la importancia de abordar el tema en el entorno escolar para promover la alfabetización científica y el pensamiento crítico. A través de una clase estructurada en etapas: diagnóstica, expositiva y lúdica, se buscó evaluar y ampliar el conocimiento de los alumnos sobre los organismos genéticamente modificados (OGM), sus beneficios, riesgos e implicaciones sociales y ambientales. Los resultados demostraron un progreso significativo en la comprensión de los estudiantes después de la intervención, con un aumento significativo en los promedios de aciertos y una mayor participación en los debates. Basándose en autores como la FAO (2017), Paine et al. (2005) y Schurman & Munro (2010), entre otros, el estudio evidencia que las metodologías interactivas y contextualizadas son eficaces para suplir las lagunas conceptuales y formar ciudadanos más conscientes y preparados para participar en los debates sobre seguridad alimentaria y biotecnología. La evaluación diagnóstica inicial reveló un promedio general de solo el 23,6 % de aciertos, lo que pone de manifiesto las deficiencias en la comprensión del tema. Cuestiones específicas como la definición, la finalidad y los ejemplos de transgénicos obtuvieron bajos índices de aciertos, que oscilaron entre el 15 % y el 32 %. Tras la aplicación de la propuesta pedagógica, los alumnos mostraron una mejora significativa, alcanzando una media de 4,2 puntos sobre 5 en la evaluación final. En la etapa lúdica, el 89 % de la clase participó activamente en la actividad y el 43 % de los estudiantes obtuvo un rendimiento superior, con aciertos superiores

al 80 % de los conceptos discutidos oralmente. Estos datos refuerzan el impacto positivo de las estrategias didácticas que priorizan el protagonismo de los estudiantes y la contextualización del contenido científico con temas actuales y socialmente relevantes.

Palabras clave: Alimentos Transgénicos. Organismos Genéticamente Modificados (OGM). Biotecnología.

1 INTRODUCTION

GMO foods are products obtained from Genetically Modified Organisms (GMOs), in which genes from one species are transferred to another with the aim of introducing specific characteristics, such as resistance to pests or nutritional improvement. According to a report by the Food and Agriculture Organization of the United Nations (FAO), transgenic foods can contribute to global food security, especially in regions where food production is limited by factors such as pests and diseases (FAO, 2017, p. 23). However, the introduction of GMOs also raises concerns about food security, biodiversity, and dependence on companies holding patents on GMO seeds (Klüber et al., 2019, p. 456).

Genetic modification of food is a complex process, but one that offers important opportunities. For example, golden rice, a type of transgenic rice enriched with beta-carotene, may help combat vitamin A deficiency in populations that rely on rice as a staple food (Paine et al., 2005, p. 204). However, the safety of these foods continues to be the subject of debate among scientists and consumers. Some studies point to possible risks, such as allergies or toxicity, although most research indicates that they are safe for human consumption (Sunday; Ginebordrette, 2018, p. 123). In addition, the labeling of GM foods is a controversial aspect: while some countries require clear identification, others do not (Schurman; Munro, 2010, p. 145).

"Topics related to biotechnology such as transgenics have started to be discussed at school, but generally students have an idea that does not go beyond common sense" (Lourenço and Reis, 2013). In this context, discussing transgenic foods in the school environment is essential to promote scientific literacy and stimulate critical thinking. By exploring the biological, ethical, and environmental aspects of GMOs, students can better understand the complexities involved in the production and consumption of these foods. Such an approach not only enriches the curriculum with current and relevant topics, but also prepares young people to participate in informed debates on issues affecting food security and global sustainability.

Another study conducted by Souza et al. (2023) investigated the perception of elementary school students about transgenic foods in a school in Mato Grosso. The methodology involved lectures, playful activities and practices of extracting DNA from onions, followed by debates in the classroom. The results show that these strategies enable greater conceptual understanding and engagement of students with the content, making learning more meaningful and collaborative.

In addition, Silva & Krauzer (2022) highlight the relevance of addressing socioscientific aspects in biology teaching through didactic sequences that compare transgenic,

conventional, and organic foods. In this type of interdisciplinary approach, students are encouraged to analyze different views and social impacts, promoting critical reflection and argumentation based on competencies that are central to contemporary scientific literacy.

Knowing that the BNCC is a guiding document of content to guide the themes to be addressed in basic education, it is important to make a pertinent description of the themes in the BNCC (2018). The National Common Curricular Base (BNCC) addresses contemporary topics relevant to the integral education of students, including issues such as transgenics, within the area of Natural Sciences and their technologies with a focus on interdisciplinarity, taking into account global/local issues that involve science and technology.

Due to the importance of working with contemporary issues in which transgenics are included, we can focus on the clarifications described by the Chamber of Basic Education of the CNE in its resolution No. 7/2010 of December 14, which specifies in:

> Art. 16 - The curricular components and areas of knowledge must articulate in their contents, based on the possibilities opened by their references, the approach to comprehensive and contemporary themes that affect human life on a global, regional and local scale, as well as in the individual sphere. Topics such as health, sexuality and gender, family and social life, as well as the rights of children and adolescents, according to the Statute of the Child and Adolescent (Law No. 8,069/90), preservation of the environment, under the terms of the national policy of environmental education (Law No. 9,795/99), education for consumption, tax education, work, science and technology, and cultural diversity should permeate the development of the contents of the common national base and the diversified part of the curriculum' (CNE/CEB, 2010, p. 05)

The class taught to explore the theme aimed to understand the concept of transgenic foods, the analysis of benefits and risks, in addition to developing the critical thinking necessary to evaluate information and make informed decisions based on a principle of scientific and social analysis, through pedagogical processes that will be described below.

The objectives of this work are focused on the promotion of scientific literacy, the development of critical thinking and the understanding of biological, social and ethical aspects related to transgenic foods in Elementary School. By addressing this contemporary and relevant theme through interactive and participatory methodologies, it seeks to provide students with meaningful and contextualized learning, connecting school content to social reality and global issues involving science and technology.

According to Brandão et al. (2022), teaching by investigation and the comparison between transgenic, organic, and conventional foods contribute to a more critical and grounded reflection, stimulating the analysis of different perspectives and social impacts. The choice of transgenic foods as a thematic axis is in line with the guidelines of the National

Common Curricular Base (BNCC, 2018), which advocates the approach of interdisciplinary themes capable of articulating science, society and technology.

Another fundamental objective of this proposal is to identify and overcome the conceptual gaps related to biotechnology and GMOs, often present in the school environment, as demonstrated in recent studies. Ventorim et al. (2021) point out that most high school students have a limited understanding of transgenic foods, based on superficial or mistaken information.

Thus, the application of a didactic sequence structured in stages of diagnosis, theoretical exposition and playful activity aims to create opportunities for conceptual reconstruction through pedagogical mediation. As Franco et al. (2021) reinforce, the use of didactic games in the teaching of Biology favors the active participation of students and facilitates the understanding of complex concepts. In the opinion of Rosadas (2012), the use of educational games reflects positively on the process of interaction with the contents experienced, in order to facilitate the understanding and application of knowledge, in addition to developing cognitive, affective and psychomotor skills, as well as inducing discussion among those involved in the game, reverberating the assimilation of the concepts explained in the themes addressed.

In addition, Santana, Mota, and Lorenzetti (2022), when analyzing works presented at ENEBIO and ENPEC, demonstrate that strategies such as teaching by inquiry and experimental practices strengthen students' intellectual autonomy, allowing them to position themselves critically in the face of contemporary challenges. Therefore, the objectives of this work aim not only at the assimilation of contents, but at the integral formation of students.

In this sense, the proposal of the work goes beyond the simple transmission of content, seeking to build a learning environment that values student protagonism, evidence-based argumentation and the development of essential skills for the formation of critical, conscious and participatory citizens.

In view of this, the role of the teacher as a mediator of knowledge becomes essential, especially when it comes to content that involves scientific controversies and social impacts, such as transgenics. Science teaching should favor the development of argumentative capacity and critical analysis, providing students with opportunities to reflect on the ethical, economic, and environmental implications of these technologies (Delizoicov; Angotti; Pernambuco, 2011).

Recent studies such as that of Santana et al. (2022) emphasize that activities based on problematization and teaching by inquiry promote greater engagement and understanding of students, as they favor the active construction of knowledge. Thus, by incorporating

interactive didactic strategies based on the principles of scientific literacy, it is possible to overcome traditional and fragmented teaching, promoting a more critical, contextualized and citizenship-oriented education, central aspects recommended by the BNCC (BRASIL, 2018).

2 METHODOLOGY

The present research adopted a qualitative and quantitative approach, since it sought to understand the perceptions, reflections and cognitive transformations of the students from a pedagogical intervention on transgenic foods at the same time that it was based on statistical data to obtain the results. The analysis was centered on the understanding of the meanings attributed by the subjects to the experiences that were lived in the classroom. This methodological choice is based on the perspective that:

> The qualitative perspective is characterized by a detailed and in-depth study of the research objects in their natural contexts, seeking to understand the phenomena from the perspective of the participants. The emphasis is on the description, interpretation and understanding of the meanings attributed by the subjects to their actions, relationships and social constructions. (LÜDKE; ANDRÉ, 2014, p. 12)

Likewise, quantitative research uses an approach of structured elements, such as questionnaires and tests, allowing the specific measurement of the phenomena investigated and the generalization of the results to larger populations. Rauteda (2025) points out that this type of research, based on the positivist paradigm, is effective for testing pedagogical methods and verifying cause-effect relationships between interventions and results, with statistical validity and the possibility of application in large populations.

When interconnected to educational environments, the adoption of structured instruments, such as diagnoses, tests and/or questionnaires, enables accurate measurements of the effects of pedagogical strategies, contributing to informed decision-making. Furthermore, despite limitations related to the complexity of the school context and the social diversity of the subjects, quantitative research continues to be a robust tool, especially when interconnected with research with qualitative approaches, expanding the understanding of educational phenomena.

2.1 DETAILS OF THE INTERVENTION

The research included students from the Ermelinda de Lucena Barbosa Municipal School, located in the municipality of Surubim, in the Agreste region of the interior of Pernambuco. The participants were students from the 7th grade "B" class in a total of 28

students from the morning shift, where the intervention in the morning was applied in the respective Science classes in two hours/classes made available by the acting teacher.

The choice of the theme "transgenic foods" was due to its potential for articulation between: science, technology and the environment, as provided for in the competence of the area of Natural Sciences. An approach like this provides the student with reflective and grounded scientific participation for contemporary approaches.

The methodological proposal, therefore, aimed to promote meaningful learning through practices involving prior diagnosis, dialogued lecture, strategies and formative evaluation. This methodological construction is supported by Resolution CNE/CEB No. 7/2010, which recommends possible articulations between school content and major themes of social relevance that impact human life, such as health, science and technology, in addition to conscious consumption.

Thus, the pedagogical intervention described below, structured in the format of a lesson plan, presenting the didactic sequence that guided the teaching-learning process in the 7th grade class, highlighting the objectives, stages and resources used under evaluation criteria that will be described and debated fundamentally in the results and discussions.

In addition, the use of didactic strategies that are based on socio-scientific themes, such as GMOs, is supported by works by authors such as Hodson (2003), who defends the teaching of Science as a socio-political practice and argues that the science taught should contribute to the formation of more critical and active citizens. According to Aikenhead (2006), by integrating science with social, cultural and technological contexts, students' understanding of the impacts of science on their daily lives is expanded, favoring a scientific education that is closer to reality and youth interests. These references emphasize the relevance of the pedagogical intervention proposed in this study.

Table 1

Didactic sequence based on the National Common Curricular Base

Stage	**Description of the activity**	**Didactic objective**	**BNCC Competency(s)**	**BNCC Skill(s) (Science – EF07CI)**
1. Initial Diagnosis	Application of a questionnaire with 5 multiple-choice questions about transgenic foods.	Identify students' previous knowledge.	Competency 1: Value and use historically constructed knowledge. Competency 3: Argue based on facts.	EF07CI01 – To assess the implications of the use of biotechnologies in different contexts and their impacts on health and the

				environment.
2. Expository Class	Presentation of concepts about GMOs using data show, blackboard and everyday examples.	Understand the concept of transgenics, recognize associated benefits and risks.	Competency 2: Understand and apply concepts from the sciences. Competency 6: Use digital technologies critically.	EF07CI01 / EF07CI02 – Identify and evaluate applications of science and technology in everyday life.
3. Conceptual Debate	Guided discussion about different points of view on GMOs.	Stimulate critical thinking and respect for the diversity of opinions.	Competency 3: Argue based on facts. Competency 8: Know and value the diversity of knowledge.	EF07CI01 / EF07CI06 – Discuss risks and benefits of different technological processes.
4. Playful Activity	"True or False" game: students classify and justify statements about transgenics.	Fix concepts through active methodology and promote engagement.	Competency 4: Use different languages. Competency 10: Act personally and collectively with autonomy and responsibility.	EF07CI02 – Identify and interpret scientific information in different means of dissemination.
5. Final Diagnosis	Reapplication of the same questions as the initial diagnosis to verify the evolution of learning.	Evaluate the effectiveness of the pedagogical intervention.	Competency 7: Argue based on data. Competency 9: Exercise self-knowledge and empathy.	EF07CI01 / EF07CI02 – Compare and analyze changes in opinion or understanding after acquiring new knowledge.

Source: Prepared by the authors with data from the research.

Based on the assumption in question, the didactic methodology adopted is part of the planning in line with the National Common Curricular Base (BNCC), which guides the inclusion of contemporary themes relevant to the integral formation of students, also promoting interdisciplinarity. Thus, the inclusion of GMOs in the methodological and curricular planning contributes not only to the fulfillment of the competencies and skills provided for in the BNCC, but also to the construction of a contextualized and socially engaged scientific education.

2.2 DEVELOPMENT OF THE INTERVENTION

The class entitled "Transgenic foods: a scientific and social approach" aimed to promote an in-depth understanding of the concept of transgenic foods, as well as their associated benefits and risks. Initially, a brief diagnosis (survey) was applied to verify the students' previous knowledge related to biotechnology and transgenic foods. The initial diagnosis consisted of five objective multiple-choice questions, as described in Table 1:

Table 2

Description of the questions and answers of a survey on the subject of transgenics with 28 students from a public school in the agreste region of Pernambuco

Issues	Questions	The	B	C
1	What is a GMO food?	Food with a lot of sugar	Food with genes changed in the laboratory.	Organic food.
2	Why are GMO foods used?	To resist pests and grow better	To make food more expensive.	To change the color of food.
3	Which of these is an example of a transgenic?	Soybeans resistant to plant poison.	Mineral water.	Cooked rice.
4	How is a transgenic food produced?	Mixing two types of fruits.	Changing plant genetics in the lab.	Planting in fertile soil.
5	Scientists are sure that GMOs are 100% safe.	Yes, they all are.	It is not yet known for sure.	No, everyone is bad.

Source: Prepared by the authors with data from the research.

Then, the expository class was held with the support of pedagogical resources such as data show, blackboard and pilot.

During the lecture, the initial concepts were presented, with questions to identify and adapt the methodology to the students' level of knowledge. From this diagnosis, a conceptual debate followed, promoting the exchange of ideas and the collaborative construction of knowledge.

In the later stage, as a way to assist the students' knowledge process, a playful activity called "True or False" was applied. In it, the students formed a circle, passing a box containing

various concepts, until it stopped at someone, who should read the concept and classify it as true or false, justifying their answer. After each statement, a discussion was promoted on the theme, deepening the reasons that led to the choice of the answer.

This activity aimed to promote discussion and debate about transgenic foods, develop critical thinking skills and stimulate the active participation of students. The class evaluation was carried out based on the students' participation in the activities, the quality of the discussions and the ability to argue.

The final diagnosis was based on the same principles as the questions elaborated in the initial diagnosis, in order to assess the students' knowledge after applying the lecture. Thus, the same questions addressed in table 01 were once again exposed: (1) What is a transgenic food? (2) Why are GMO foods used? (3) Which of these is an example of a transgenic crop? (4) How is a transgenic food produced? (5) Scientists are sure that GMOs are 100 percent safe. The students' responses to applied diagnosis will be exposed in the results of this study.

Statistical analyses were carried out using the *BioEstat 5.3* program (AYRES et al., 2007), developed by the Mamirauá Civil Society. For a better understanding of the results, the program facilitates the analysis of data from grouped data.

3 RESULTS

The results obtained clearly show that there has been a significant advance in students' understanding of transgenic foods. From the application of an initial diagnostic activity with students of the 7th grade of Elementary School, it was possible to observe that the initial knowledge of the class about transgenic foods was quite limited. The evaluation had five objective questions, and the overall average of correct answers was only 1.8 out of a total of 5 possible points.

Conceptual gaps are evidenced on scientific concepts analogous to biotechnology, mainly interconnected with transgenic foods, in line with recent analyses in the literature. Ventorim et al. (2021) observed that about 70% of the participants in another study recognized that the information disclosed about transgenics was insufficient to form a reflective and consistent opinion on the subject. Such evidence reinforces the importance of initial diagnosis in the classroom to identify conceptual gaps and guide more effective pedagogical interventions.

In addition, it should be considered that the teaching of Science should not be restricted to the transmission of ready-made and decontextualized content.

"Scientific literacy goes beyond the memorization of concepts: it implies developing the ability to argue based on evidence, interpret information and understand the functioning and limitations of science, promoting engagement with contemporary issues that impact society" (MASSARANI; MOREIRA, 2020, p. 78).

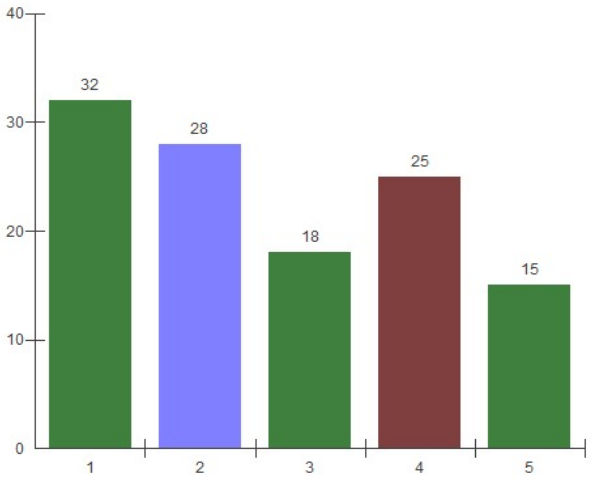
However, it is necessary that pedagogical proposals prioritize the development of scientific skills that can enable students to act as critical and severely informed citizens. As Sasseron and Carvalho (2008) point out, the teaching of Science should promote the construction of meanings for knowledge, bringing it closer to the social reality of the student, stimulating him to make informed decisions, starting from scientific literacy. In this sense, in order to better understand the students' conceptual panorama on biotechnology, especially with regard to transgenic foods, an initial diagnostic evaluation was carried out, the results of which are presented in Figure 01.

The pedagogical application allowed not only significant conceptual gaps, but also to find an orientation for subsequent pedagogical interventions, as stated by Luckesi (2011) and Perrenoud (1999) where the most effective process directs them to the real needs of the class. The initial strategy evidenced the value of the diagnosis as an essential tool for the planning of educational actions, contextualized and aligned with the conceptual level of the students, enabling a more facilitated conceptual understanding.

In addition, this initial stage enables the prior mapping of students' spontaneous conceptions, enabling the teacher to work more precisely in the process of re-signification of concepts, as highlighted by Ausubel (2003), when he states that meaningful learning occurs when new information is connected in a substantive way to prior knowledge. Such a connection makes the content more relevant, engaging the student in an authentic way in the teaching-learning process.

Figure 1

Percentage distribution of correct answers in the initial diagnostic evaluation



Source: Prepared by the authors with data from the research, using the BioEstat 5.3 software (AYRES et al., 2007).

Analyzing the data by question, the first one that addresses the definition of transgenic foods had 32% of correct answers. In the second, related to the purpose of the use of genetically modified organisms in food production, 28% of the students answered correctly. The third question, which sought to identify examples of these foods, had only 18% of correct answers. The fourth, which deals with the process of producing transgenics, obtained 25%, and the fifth, which discussed food safety and the possible risks of these products, got 15% of correct answers. The overall average among the five questions was 23.6%, evidencing a starting point with many conceptual gaps.

Many students have confused transgenics with organic foods. This initial difficulty reinforces what Schurman and Munro (2010) point out in their research, as they report that there is a lack of well-founded information about biotechnology, both in school and in other training spaces.

In view of this scenario, the pedagogical proposal that combined theoretical exposition, debate and playful activity proved to be quite effective. The dynamics of "True or False" stimulated the participation of the class in a light and relaxed way, favoring an environment of exchange of ideas and collective construction of knowledge. The result was very positive: about 89% of the students actively participated and the average number of correct answers reached 73%, with emphasis on 43% of the students who got more than 80% of the concepts contained in the playful activity right.

For a possible analysis of the pedagogical data obtained from the playful activity by the participation of the students, simple percentage calculations were used based on the total

of 28 students in the 7th grade class. As seen, the active participation rate was 89%, which represents about 25 students involved, with discussions and elaboration of personal concepts with a critical basis.

The average number of correct answers (evaluation by concept in oral form) reached 73%, which is equivalent to approximately 7 correct answers for every 10 concepts contained in the box. In addition, 43% of the students, about 12 students obtained a superior performance with correct answers above 80% of the concepts discussed. The data cited indicate the positive interaction of students and the impact with the engagement linked to the playful activity.

Table 3

Grouped data from the playful activity carried out with 28 7th grade students from a public school in the agreste region of Pernambuco

Evaluative indicator	**Percentage Value**	**Approximate quantity**
Active participation in the activity	89%	~25 students
Overall average of correct answers (by oral concepts)	73%	~7/10 hits
Students with performance above 80%	43%	~12 students

Source: Prepared by the authors with research data

These data show that when content is worked on in an interactive and contextualized way, learning becomes more meaningful. This path is defended by authors such as Domingo and Ginebrodrette (2018), who emphasize the importance of scientific literacy so that people can evaluate, based on evidence, the risks and benefits of genetically modified foods, overcoming unfounded fears or prejudices.

According to Massarani and Moreira (2020, p. 78):

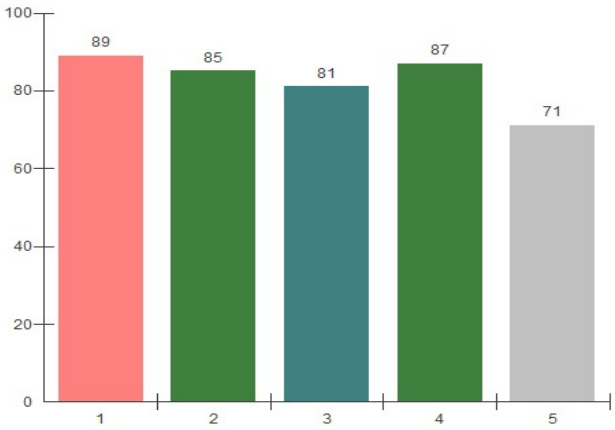
> Scientific literacy goes beyond memorizing concepts: it implies developing the ability to argue based on evidence, interpret information, and understand the functioning and limitations of science, promoting engagement with contemporary issues that impact society.

Based on this perspective, it is observed that the teaching of Science needs to favor critical thinking, thus developing the intellectual autonomy of students. When it comes to transgenics and/or GMOs, the process becomes even more relevant, and with the environment conducive to debate, interactions and reflections; Educationally, the school can

prepare subjects who are more informed and prepared to formulate socially and scientifically based data.

Figure 2

Percentage distribution of correct answers in the final diagnostic evaluation



Source: Prepared by the authors with data from the research, using the BioEstat 5.3 software (AYRES et al., 2007).

After completing the didactic sequence, which included expository moments, discussions and a playful dynamic "True or False", a new evaluation was applied with the same structure as the initial one. The results revealed significant advances in the performance of the class: the first question reached 89% of correct answers; the second, 85%; the third, 81%; the fourth, 87%; and the fifth, 71%. As a result, the overall average rose to 82.6%, which represents a jump of almost 60 percentage points in relation to the diagnostic stage.

These evidences reinforce the importance of pedagogical practices that go beyond the simple exposition of content and that place the student as the protagonist of the educational process as proposed in the activity described here. According to Lima and Oliveira (2024), active methodologies contribute to student engagement and autonomy, making the learning process more meaningful. Similarly, Medeiros and Nunes (2023) highlight that student protagonism is strengthened when the student takes an active role in the construction of knowledge, favoring more participatory and transformative pedagogical practices.

The positive impact of this methodology was even more evident in the final evaluation: the class average jumped to 4.2/5 (evaluation by number of questions). Most students were able to not only correctly identify what GMOs are, but also better understand their benefits and risks. In addition, they began to value the importance of labeling these foods (concepts worked on and discussed in the dynamic activity), pointed out as essential by 71% of the

participants, a fact that evidences the development of a critical awareness of consumer rights and the need for transparency in triggering the notion on the part of the population that will consume the food.

4 DISCUSSION

Another relevance observed was that, throughout the activities, the students began to reflect on broader issues related to transgenics, such as their potential to combat nutritional deficiencies, such as golden rice, as discussed by Paine et al. (2005). In addition, students raised concerns related to environmental impact and sustainability, themes raised by Klüber et al. (2019), which show how these technologies can be allies, but also represent challenges that need to be debated.

These observations emphasize the importance of pedagogical practices that prioritize the active participation of students. According to Delizoicov, Angotti and Pernambuco (2011), science teaching should be organized based on problematizations of everyday life, allowing students to construct meanings for what is debated in the classroom. In this context, education is responsible for promoting critical and conscious sense, relying on active methodologies to promote the improvement of essential skills for the sociocultural context, where the individual requires a keen critical sense to solve problems that run through all spheres of collective reality.

The "true or false" dynamic, used in the intervention, proved to be effective in this aspect, by providing a relaxed environment, although intellectually instigating, where error was not penalized, but rather understood as part of the learning process. Through playful didactics, students were able to test their knowledge without the fear of making mistakes, which contributed to the reduction of tension often associated with traditional assessments. The dynamics not only facilitated the understanding of the concepts worked on, but also stimulated cooperation and involvement. This approach favors, according to Freire (1996), a dialogical education, in which knowledge is collectively constructed, through listening, speaking and critical reflection.

To theoretically support this pedagogical proposal, research that discusses the use of active methodologies in the teaching of Biology was consulted. An example is the study by Franco et al. (2021), presented at ENEBIO, which reviewed the use of didactic games in this area. The authors point out that the use of playful resources contributes significantly to arousing the interest of students and deepening the understanding of scientific concepts, including topics such as transgenics.

The results of this pedagogical proposal confirm that teaching strategies based on the active participation of students and the contextualization of contents play a fundamental role in the formation of more informed and critical citizens. By inserting the student as a subject of the process, involved in contexts that dialogue with their reality, learning ceases to be fragmented and starts to make sense in their daily life a construction of more significant learning.

This practice enhances, according to Moran (2015), the use of methodologies that value action, experimentation and dialogue, considered essential to form subjects capable of continuous learning. The school, in this sense, plays an essential role in bringing students closer to current and complex issues, such as biotechnology and food security, encouraging them to think and participate in debates that directly impact society and the environment.

In connection, as already mentioned in the introduction, Santana, Mota and Lorenzetti (2022), based on a systematic review of studies presented at ENEBIO and ENPEC, reinforces the effectiveness of methodologies such as teaching by investigation and playful activities. According to the authors, these strategies favor student engagement and the construction of knowledge in a critical and contextualized way, allowing students to actively participate in their own learning.

The feasibility of adopting pedagogical activities like this encompasses a broad school matrix, which in line with the National Common Curriculum Base (BNCC), can become a powerful tool for the development of scientific literacy, supported by content/theoretical practice in council with practice starting from reflection, often cited by Freire (2021), praxis is essential as a union between action and reflection, allowing the transformation of reality.

5 CONCLUSION

This study demonstrated that addressing the topic of transgenic foods in an interactive and contextualized way in the school environment is fundamental to promote scientific literacy and critical thinking among students. The pedagogical intervention, which combined moments of diagnosis, exposure and playful activities, enabled not only a significant increase in conceptual knowledge about Genetically Modified Organisms (GMOs), but also the expansion of students' reflection on the social, environmental and ethical implications associated with the theme.

The data obtained showed evident progress: from a very restricted initial knowledge, the students began to demonstrate mastery of the main concepts and to actively participate in critical and reasoned discussions. This result reinforces the importance of teaching

methodologies that go beyond the simple transmission of content and, on the contrary, stimulate participation, argumentation and the development of intellectual autonomy.

With an emphasis on the results obtained, the improvement in learning based on authors such as Franco et al. (2021) and Domingo and Ginebrodrette (2018), among others who emphasize interactive education through playful activities, helping to change behavior, especially in the field of environmental and scientific education, Silva and Ferreira (2022) where education is discussed as a promoter of changes in values and attitudes towards topics such as sustainability, consumption and health.

Foundations such as these reinforce educational themes and their evident relevance through intervention with students and students in public education at the elementary level. The importance of addressing critical knowledge for a democratic and transformative education, cultivated and worked intentionally in schools (PAUL; ELDER, 2014, p. 2).

In addition to broadening students' conceptual understanding of transgenics, the pedagogical experience demonstrated the importance of connecting curricular content with everyday issues. By relating science and society, students came to understand that knowledge is not isolated in books, but is part of the decisions we make daily, such as in the choice of food we consume.

This type of approach contributes to the construction of an education closer to the students' reality, arousing curiosity, critical thinking and the feeling of belonging to the learning process. It is also worth noting that activities such as those developed in this study favor not only scientific learning, but also the strengthening of social and communicative skills.

Collective work, classroom discussions and the freedom to express opinions created an environment of exchange and respect, essential for the integral development of students. This experience reinforces the idea that teaching science goes beyond transmitting data: it is an opportunity to form individuals who are more aware, collaborative, and prepared for the challenges of the contemporary world. Contributing to the production of knowledge in an attractive way, overcoming recurring barriers imposed by the current educational scenario. For Brant and Velasquez (2018), the importance of practical activities in the teaching-learning process with the union of theory and practice are responsible for the construction of complete knowledge.

And in conjunction with the data reported so far, the positive achievement of the results agrees with the evolution of the students, enabling other studies to adopt the same line of research in the same interdisciplinary methodological scientific bias that obtains the central focus which is the students' learning. Therefore, this approach in addition to demonstrating a

potential adaptable to different educational contexts, thus encouraging protagonism and contributing to the renewal of pedagogical practices, especially in the teaching of Science.

The analysis of the intervention process allows us to highlight the relevance of active listening in the school environment. Considering the perceptions, doubts and interests of the students during the didactic sequence (Table 01), the teaching practice becomes more responsive and student-centered. This openness dialogues with what Sacristán (2013) says, where the classroom is transformed into a space for the collective construction of knowledge, where a new meaning is gained in the light of the reality experienced by the students.

The integration between theory and practice was a determining factor for the success of the proposal. By connecting scientific concepts with everyday situations, highlighted during the debate. As Morin (2002) points out, knowledge must be contextualized in order to make sense, and it is essential to overcome disciplinary fragmentation and promote a broader and more integrated understanding of the phenomena. Bassoli (2014) found, among teachers and researchers, a unanimity about the importance of carrying out practical activities in the teaching-learning process of the natural sciences.

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