Air pollution as a proposal for chemistry teaching

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ABSTRACT

The increase in air pollution has caused harmful effects on fauna, flora and changes in biogeochemical cycles, making it crucial to raise society's awareness in mitigating and reducing these pollutants in the air. In this way, environmental awareness during basic education through Chemistry has become decisive for the social formation of the entire community. The objective of this work was to apply an interdisciplinary approach to the Teaching of Chemistry in basic education, through a thematic workshop using the Plickers platform as a complementary technological resource for the application of questionnaires. In addition, a gamification (board game) was carried out to promote teaching in a more interactive, dynamic and relaxed way, arousing greater interest among students. Finally, the results obtained helped in the teaching-learning process, highlighting new skills of the students that are often omitted in traditional teaching.

Keywords: Chemistry Teaching, Atmospheric Chemistry, ICT.

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INTRODUCTION

Anthropogenic interference in the basic systems for sustaining life on Earth has been damaging the environment with harmful effects on fauna, flora, and changes in biogeochemical cycles (Bowler *et al*., 2020; Lima *et al*., 2022). Increasing environmental pollution, climate change and environmental inequality are increasingly evident in the daily life of society (Rosetto; Gregory and Raupp, 2022; Souza *et al.,* 2023). According to the National Cancer Institute, environmental pollution may be correlated with about 19% of annual records of different diseases such as cancer, which justifies the development of public policies to protect the environment (Ministério da Saúde 2021).

Among the different environmental compartments (water, soil, and atmospheric air), air pollution is the one that has caused the most harmful effects on the population, in addition to the highest number of deaths (Landrigan *et al*., 2018). Thus, it is crucial to evaluate the different polluting substances present in the air, in addition to identifying their emission sources and, thus, creating a diagnosis that minimizes the release of these pollutants at the local and global level Li *et al.,* 2020; Vieira *et al.,* 2023).

Actions to raise society's awareness of environmental preservation must be continuously linked to basic education, allowing the construction of critical thinking in order to involve subjects in the challenges of contemporary society (De Oliveira *et al.,* 2016). According to competence 2, proposed by the National Common Curricular Base (BNCC) for science teaching, it is essential that schools stimulate the exercise of students' intellectual curiosity, so that the constant activity of reflection and critical analysis of them can occur (Brasil, 2018). Thus, studying environmental chemistry and chemical phenomena occurring in the atmosphere becomes of paramount importance for the social, professional and conscious formation of subjects during basic education.

It is worth noting that the teaching and learning process of Chemistry content must integrate significant interdisciplinary knowledge for social, economic, political, and environmental developments (Tavares *et al.,* 2021; Diniz *et al.,* 2021). In this sense, the environmental theme discussed in High School Chemistry classes helps in the development of social values, behaviors and attitudes that favor the student's critical sense, strengthening the awareness of their present and future actions in the individual and collective life of society (De Oliveira *et al.,* 2016; Mendonça, 2015).

However, the complexity of chemistry content, the educational environment, and the conditions under which the subjects are discussed may be the biggest challenge in arousing students' interest in this curricular component (Silva *et al.,* 2021). Thus, the use of technological tools (Information and Communication Technologies - ICT) as a complementary resource to the training of students can be a facilitator to make the teaching of scientific concepts clearer, interactive, more attractive and contextualized with the student's reality (Dionízio *et al.,* 2019). In addition, these

methodologies strengthen the democratization of access to education and technology, which allows students to take ownership of the information made available (Dionízio *et al.,* 2018; 2019). Added to this, gamification has been an educational strategy that allows you to turn tasks or activities, normally tedious or uninteresting, into something fun and challenging for students. In addition, this methodology allows student engagement, improving learning and highlighting new skills that are missing in traditional teaching (Leite, 2020).

Therefore, the objective of this work was to approach in an interdisciplinary way the contents of Chemistry with the environmental problems about atmospheric pollution, with the students of the High School of the Federal Institute of Education, Science and Technology Fluminense *Campus* Itaperuna – RJ. As a result, a workshop was held at the VI Congress of Interdisciplinarity of Northwest Fluminense (VI CONINF - 2022), using the *Plickers application* as a complementary technological resource for the application of questionnaires before and after the workshop. At the end, a board game was applied to approach the contents of the workshop in an interactive, dynamic and relaxed way.

METHODOLOGY

DEFINITION OF THE FIELD SCHOOL

The proposed activities were carried out at the Federal Institute of Education, Science and Technology Fluminense Campus Itaperuna – RJ. The research was carried out with students from High School Integrated to the Technical Course in Chemistry, so that it was possible to evaluate the different perspectives of students in this phase of basic education; in addition to verifying the efficiency of the interdisciplinarity addressed in the curricular components of the Chemistry Technician course.

IMPLEMENTATION OF THE THEMATIC WORKSHOP

The steps taken during the thematic workshop are listed below:

i. Application of the initial questionnaire using the *Plickers* platform to assess students' knowledge before the workshop.
ii. Presentation of theoretical contents on Atmospheric Chemistry in an expository and dialogued way. It is noteworthy that the contents addressed were presented with different images, examples of chemical phenomena, elements, molecules, among others, so that the students could correlate the theoretical contents to their daily lives.
iii. Gamification (playful activity through a board game) applying questions addressed during the thematic workshop.

iv. Application of the final questionnaire using the *Plickers platform* to assess the knowledge that the students achieved with the workshop.

Figure 1 shows the board game played with the students during the thematic workshop. The images of the questions and riddles used in the game are presented in Figure 1S of the Supplementary Material.

Figure 1: Board game.

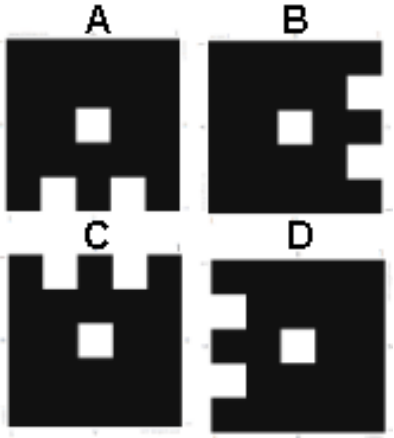
Source: The authors(2023).

DATA COLLECTION AND INTERPRETATION (USE OF THE ***PLICKERS PLATFORM)***

For the application of the initial and final questionnaires, the Plickers *platform was used*, in order to create a moment of interaction between the subjects, in addition to encouraging argumentation and scientific knowledge. The *Plickers* platform is a tool that administers quick tests, allowing the teacher to scan the answers and know in real time the performance of the class regarding the concepts covered in a class.

In this way, different QR Codes were distributed to the students. These codes, depending on the position in which they are arranged, represent a letter in the playful questionnaire that was carried out. All codes were generated by the platform itself. The students' answers were scanned by the teacher's cell phone and the application itself saved the data automatically, accounting for the performance through graphs. Figure 2 exemplifies the four positions (A, B, C, and D) for responses to the QR Codes generated by the platform, where the letter that remains at the top corresponds to the proposed question.

Figure 2: Example of the *QR Code* generated by the *Plickers platform.*



Source: *Plickers Platform* (2023).

The *Plickers* platform generates data in the form of a percentage, identifying the responses of each participant. The results were evaluated based on these data and will be presented in the next section. The *Plickers* platform is available for free in https://www.plickers.com/.

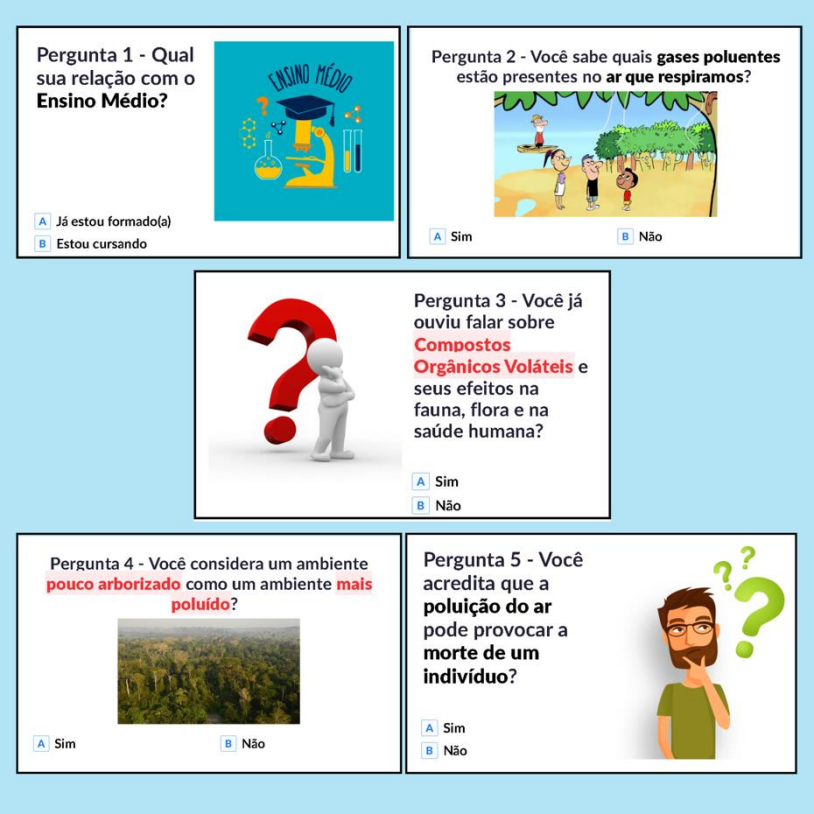
RESULTS AND DISCUSSION

INITIAL QUESTIONNAIRE

In order to understand the students' previous knowledge about the subjects covered in the workshop, an initial questionnaire was proposed through the *Plickers platform* (Figures 3 and 5). 10 optional questions were worked on and the questions were elaborated at the high school and general knowledge level. Since the questionnaire was not named, students were marked with numbers from 1 to 18. It should be noted that student 18 was not present at the beginning of the questionnaire, so he did not answer the first three questions.

Questions 1 to 5 (Figure 3) were asked in order to verify the students' knowledge about the effects of air pollution.

Figure 3: Questions 1 to 5 of the initial questionnaire constructed by the Plickers platform.

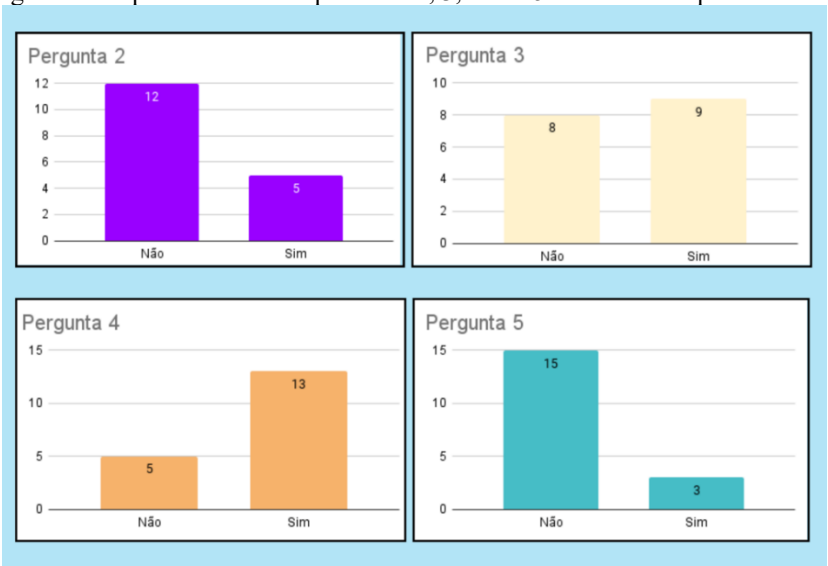


Source: The authors(2023).

Question 1 made it possible to assess the level of education of the students present, where out of 17 respondents, 16 are still attending high school.

Questions 2 to 4 highlight important issues that are present in students' daily lives. However, these subjects are conveyed quickly and without emphasis during basic training, not going over the chemical issues involved. Figure 4 shows the results of questions 2 to 5, showing how the students are integrated into the subjects addressed and how they see the proposed problem.

Figure 4: Graphs drawn from questions 2, 3, 4 and 5 of the initial questionnaire.



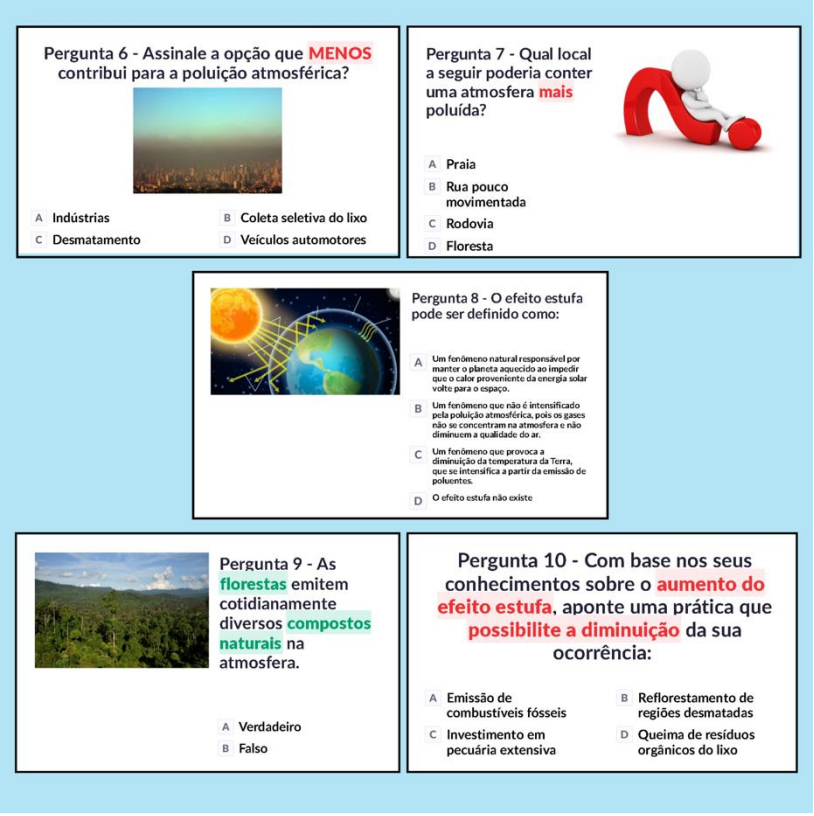
Source: The authors(2023).

From question 2, it can be observed that the majority of students (12 of them, 70%) are not aware of the substances that are present in the air we breathe. This fact proves that, despite belonging to a global and current theme, these students do not receive the necessary information during their training or are not aware of what happens around them. This statement also agrees with the results of question 5, since 15 students (83%) believe that air pollution cannot cause the death of an individual. Data from the World Health Organization (WHO) indicates that exposure to air pollution is associated with 4.2 million premature deaths each year (Karimi and Shokrinezhad, 2021). It is notorious that the subject is pertinent to the whole society, however, even with so many evident consequences, air pollution is still "invisible" and, in this way, a large part of the population ends up not being able to correlate its effects to human health, fauna and flora.

Finally, the answers obtained from question 4 demonstrate that students recognize the importance of a wooded environment, even in the face of misinformation from *fake news* about fires and deforestation.

Questions 6, 7, 8, 9 and 10 (Figure 5) address more specific questions about the theme of the workshop, in order to evaluate, together with the final questionnaire, what the students already understood and what they added about the concepts worked.

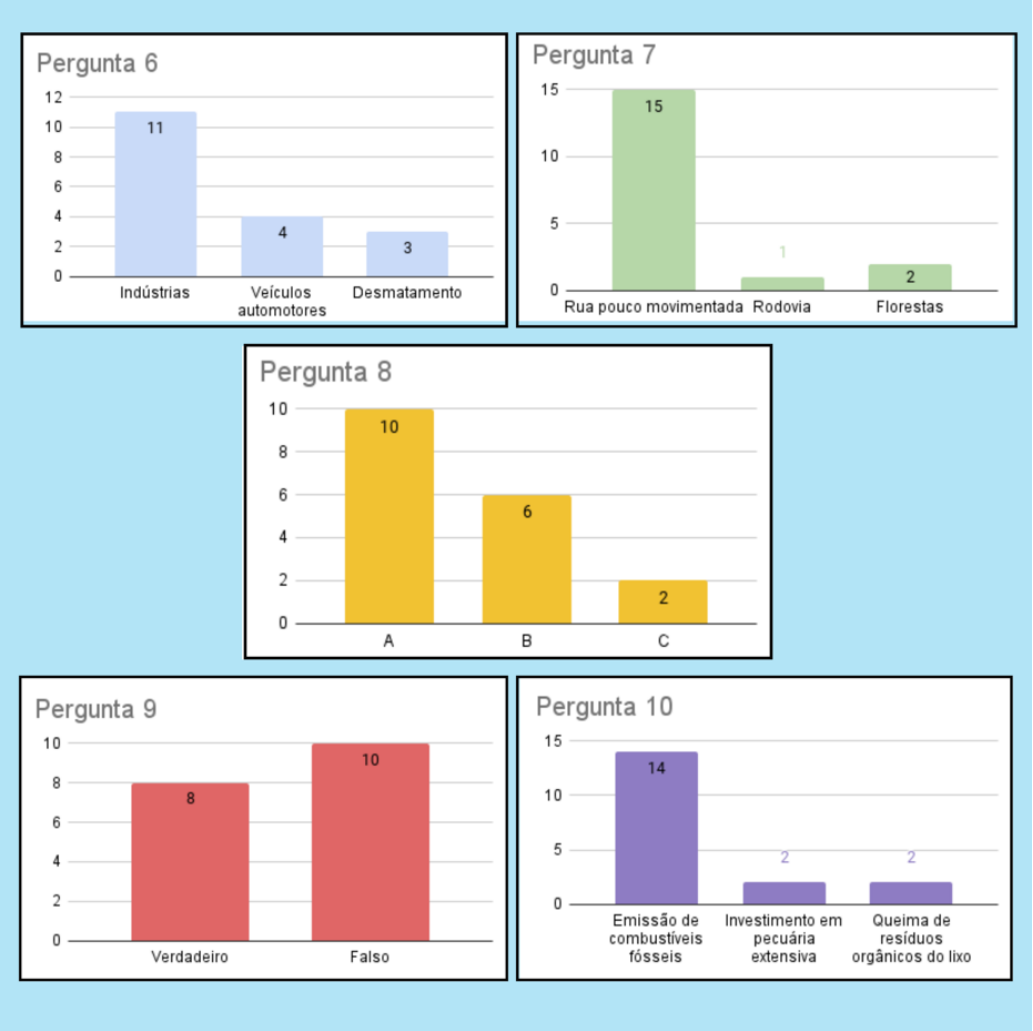
Figure 5: Questions 6 to 10 of the initial questionnaire constructed by the *Plickers platform*.



Source: The authors(2023).

Although the questions had only one correct alternative, it was not revealed to the students so that they could critically compare the results of the initial and final questionnaires. Figure 6 shows the results of questions 6 to 10.

Figure 6: Graphs drawn from questions 6, 7, 8, 9 and 10 of the initial questionnaire.



Source: The authors(2023).

Evaluating the results of question 6, it was observed that none of the students considered the selective collection of garbage as a factor that does not contribute to air pollution. However, 13 students (72%) consider industries to be less polluting. This response from the students shows the façade ideology about industries not polluting, or that cars are not sources of significant emissions. Agreeing with the statement that automobiles are not significant sources of pollutant emissions, it is observed through question 7 that 15 students (83%) consider the streets with little traffic as the most polluted, disregarding the highways that have a high circulation of motor vehicles. Probably, during the application of the questionnaire, the students were confused when answering question 7, ignoring the word "little", and only taking into account "busy street".

Questions 8 and 10 deal with students' prior knowledge about the greenhouse effect. Question 8 showed that the majority of students (10 of these, 55%) understand the basic definition of the

natural occurrence of the greenhouse effect. However, question 10 shows that none of the students considered the reforestation of deforested areas as a practice that reduces the occurrence of greenhouse effect intensification.

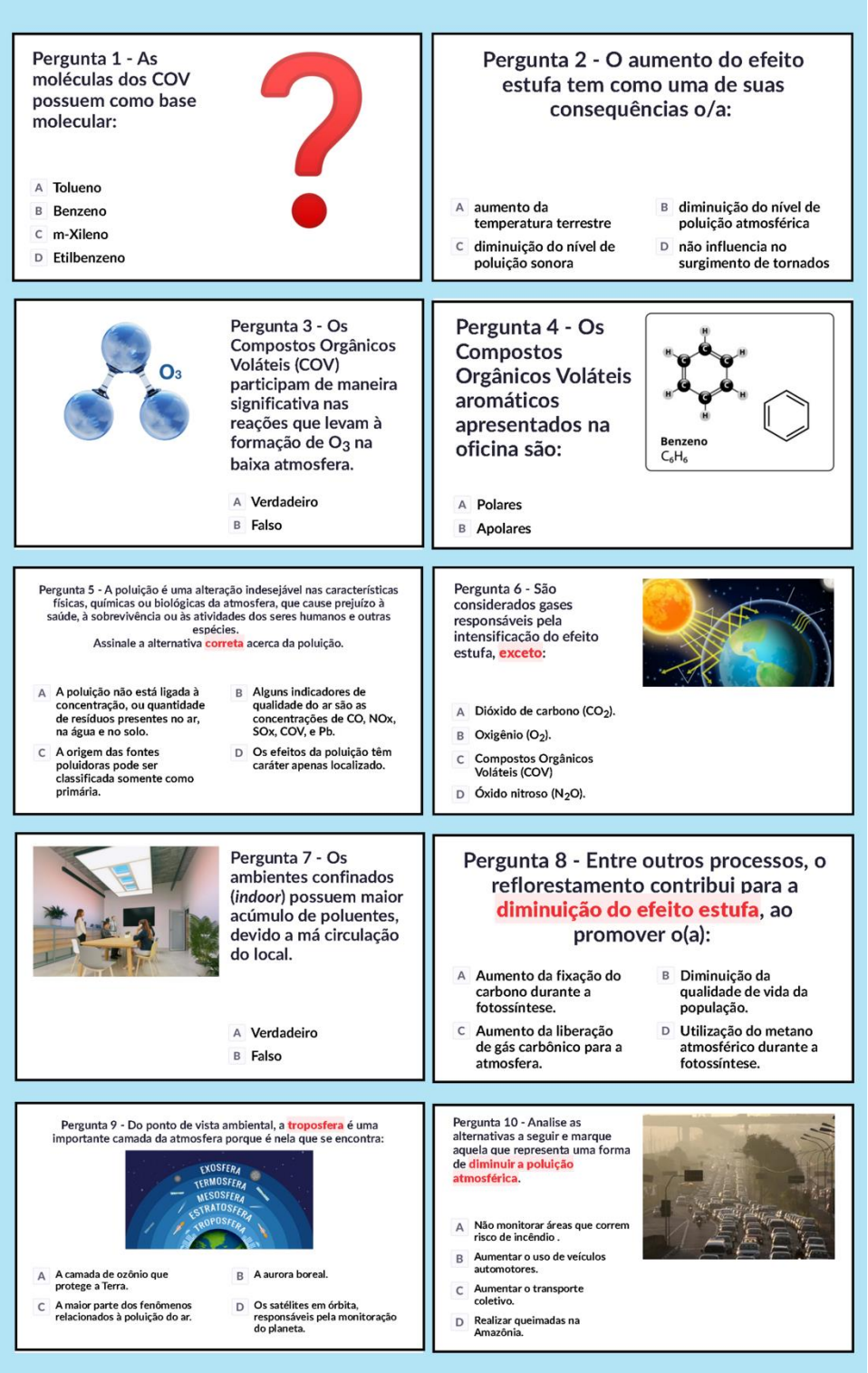
Finally, question 9 aims to assess whether students understand the biogenic cycles that forests perform. The results of this investigation point to a deficit in this type of knowledge, where 10 students (55%) do not recognize the gas exchange that forests carry out with the atmosphere (Souza *et al.*, 2023). Thus, it is noted that it is necessary that the contents addressed during basic training are correlated to everyday phenomena. With this, the student's training will go beyond basic education, promoting critical thinking and autonomy in conscious decision-making.

FINAL QUESTIONNAIRE

To evaluate the efficiency of the workshop, a final questionnaire was applied with 10 questions of easy, intermediate and difficult levels to the students. These results were used as a comparison with the initial questionnaire previously applied. The questions in this questionnaire (Figure 7) were also worked on through the *Plickers platform* and all 18 students present answered the questions. It should be noted that the final questionnaire was applied after the thematic workshop, that is, after the presentation of the expository/dialogued class and the application of gamification with the board game.

During the workshop, environmental and chemical issues were addressed, establishing a connection between all the factors presented (Figure 7).

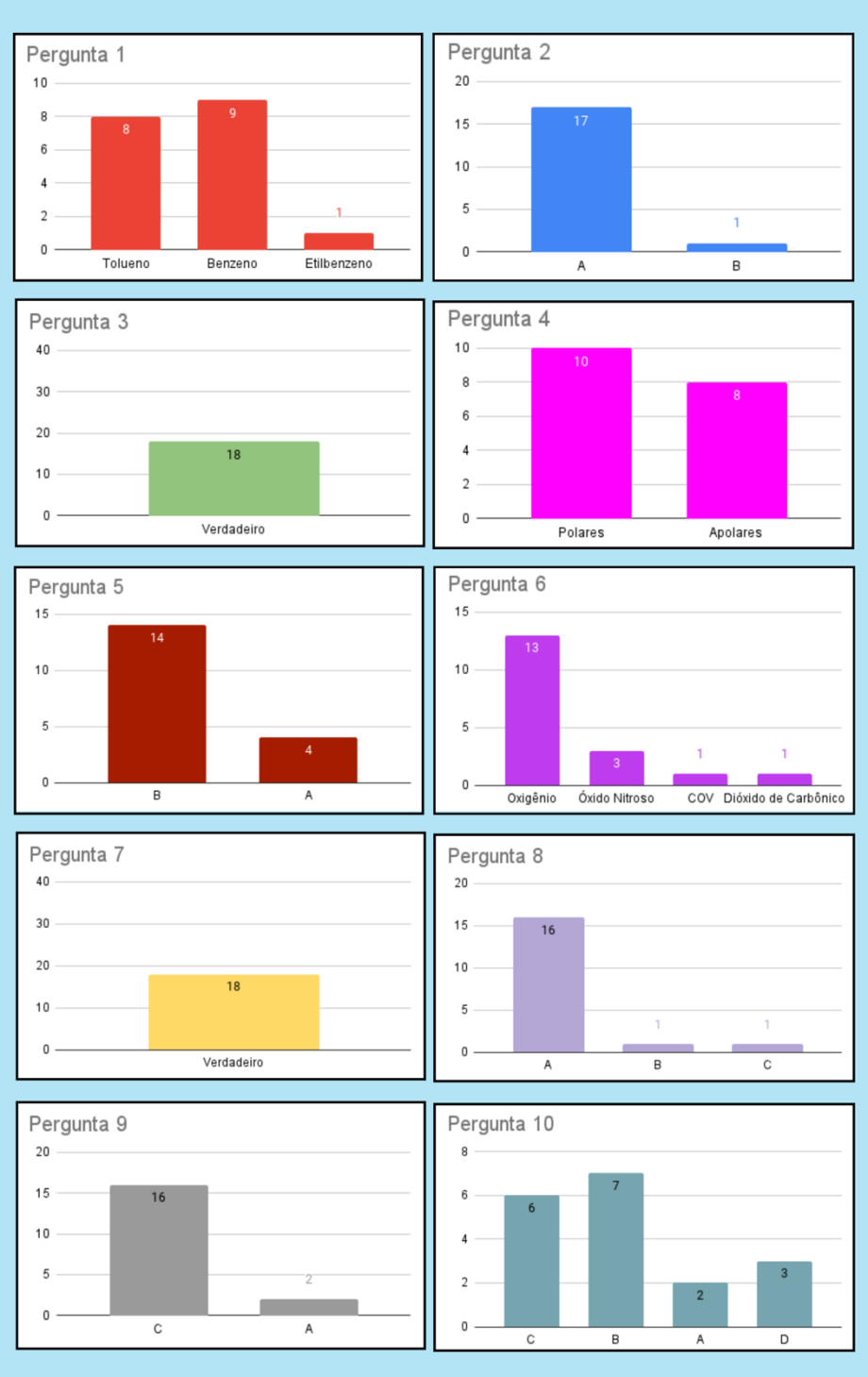
Figure 7: Questions 1 to 10 of the final questionnaire constructed by the *Plickers platform*.



Source: The authors(2023).

The results obtained through the final questionnaire are shown in Figure 8.

Figure 8: Graphs drawn from questions 1 to 10 of the final questionnaire.



Source: The authors(2023).

Questions 1 and 4 involve chemical knowledge that is part of the high school curriculum, such as molecular geometry and the polarity of substances. Question 1 showed that 9 students (50%) were able to understand through the workshop that the basic structure of the aromatic VOCs presented is benzene. It is to be expected that students will doubt this question, since all the compounds mentioned as an option (toluene, m-xylene and ethylbenzene) are derivatives of benzene and have similar characteristics. It is noteworthy that, even though the students are attending High School integrated with the Chemistry Technician, part of their training was during the COVID-19

pandemic, where face-to-face teaching was replaced by the remote teaching model. Thus, the schools suffered an educational deficit due to the new adaptations and, as a result, there was a great inequality in the elementary education of these students, which may have influenced the previous knowledge acquired by them. Question 4 showed that 8 students (44%) were able to assimilate that aromatic VOCs have a nonpolar character, demonstrating that these students were able to associate the theoretical concepts about chemistry worked in the workshop. However, it is noteworthy that 10 students (55%) considered aromatic VOCs as polar, which demonstrates the lack of understanding of the content.

Question 2 implies the consequences of the intensification of the greenhouse effect, where 17 students (94%) answered correctly, relating this intensification to the increase in the earth's temperature. It is noteworthy that there was a greater understanding of the greenhouse effect when compared to the initial questionnaire. In addition, 16 students (89%) correctly answered question 8 (of the final questionnaire) that addresses the reduction of the greenhouse effect. It is worth noting that question 10 (of the initial questionnaire), which addresses the same topic as question 8 (final questionnaire), was not answered correctly by any student. Finally, it is observed that there is a marked growth (from 0 to 16) regarding the understanding of the reforestation of deforested regions and the positive consequences that this fact promotes for the maintenance of life on Earth.

Questions 3 and 7 showed a 100% success rate regarding the subjects worked on in the workshop, since both questions portray contents that permeate the students' previous knowledge, demonstrating that the workshop was effective for the understanding of complex topics such as the formation of tropospheric ozone, something little addressed in high school. In addition, students came to understand that *indoor* environments can be up to 13 times more polluted than *outdoor* environments, something extremely worrying given that people spend 90% of their time indoors (homes, schools, work, among others) (Sanchez *et al*., 2020; Figueiredo *et al.*, 2021; Ferreira *et al*., 2021; Souza *et al*., 2021).

It is noteworthy that 14 students (78%) answered question 5 correctly, acknowledging that CO, NOx, SOx, VOC, and Pb concentrations are indicators of air quality and that local monitoring of these pollutants is crucial to maintain established quality standards (Seares *et al*., 2021; Souza *et al*., 2023). In addition, from question 10 it can be observed that students understand the basic mechanism of the greenhouse effect, but are unable to propose actions that reduce its intensification. In addition, question 6 indicates that 13 students (72%) understood which gases contribute to the intensification of the greenhouse effect.

Finally, question 9 addresses knowledge about the troposphere (the lowest layer of the atmosphere), the region where we live and where various chemical and climatic phenomena occur.

The results obtained in this question show that 16 students (89%) were able to understand that it is in this layer of the atmosphere that most of the phenomena related to air pollution occur.

FINAL THOUGHTS

The initial and final questionnaires applied in the thematic workshop on atmospheric chemistry using the *Plickers platform* and the gamification using a board game helped in the evaluation of the students' teaching-learning process; in addition to allowing the presentation of theoretical concepts in a clearer, more interactive and contextualized way with the student's reality.

The initial questionnaire presented in a direct way the previous knowledge about the subject addressed, demonstrating that many students had not yet reflected on the consequences of air pollution. In addition, this study allowed us to assess that more efficient actions should be proposed during basic education that allow these students to see themselves as protagonists in the protection and future of the environment and society. It is noteworthy that 83% of the students were unable to associate air pollution with the death of individuals. However, the results of the final questionnaire showed that the students were able to understand the contents that were worked on in the workshop. In a comparative analysis, it was observed that the question about the increase in the greenhouse effect and the practices that make it possible to reduce its occurrence presented a 100% correct answer rate in the final questionnaire.

It is worth noting that the Plickers platform used as a technological resource was useful for data generation, in addition to arousing the interest of students who effectively participated in the proposed teaching-learning process. In addition, the board game reinforced the use of active methodologies and more dynamic tools applied in the classroom, providing greater interactivity and interest among students, which promotes effectiveness in the teaching-learning process of Chemistry. Therefore, this work demonstrates in a practical way how technological tools and active methodologies bring the student closer to the educational process, making teaching contextualized and preparing the individual for social, professional and conscious formation.

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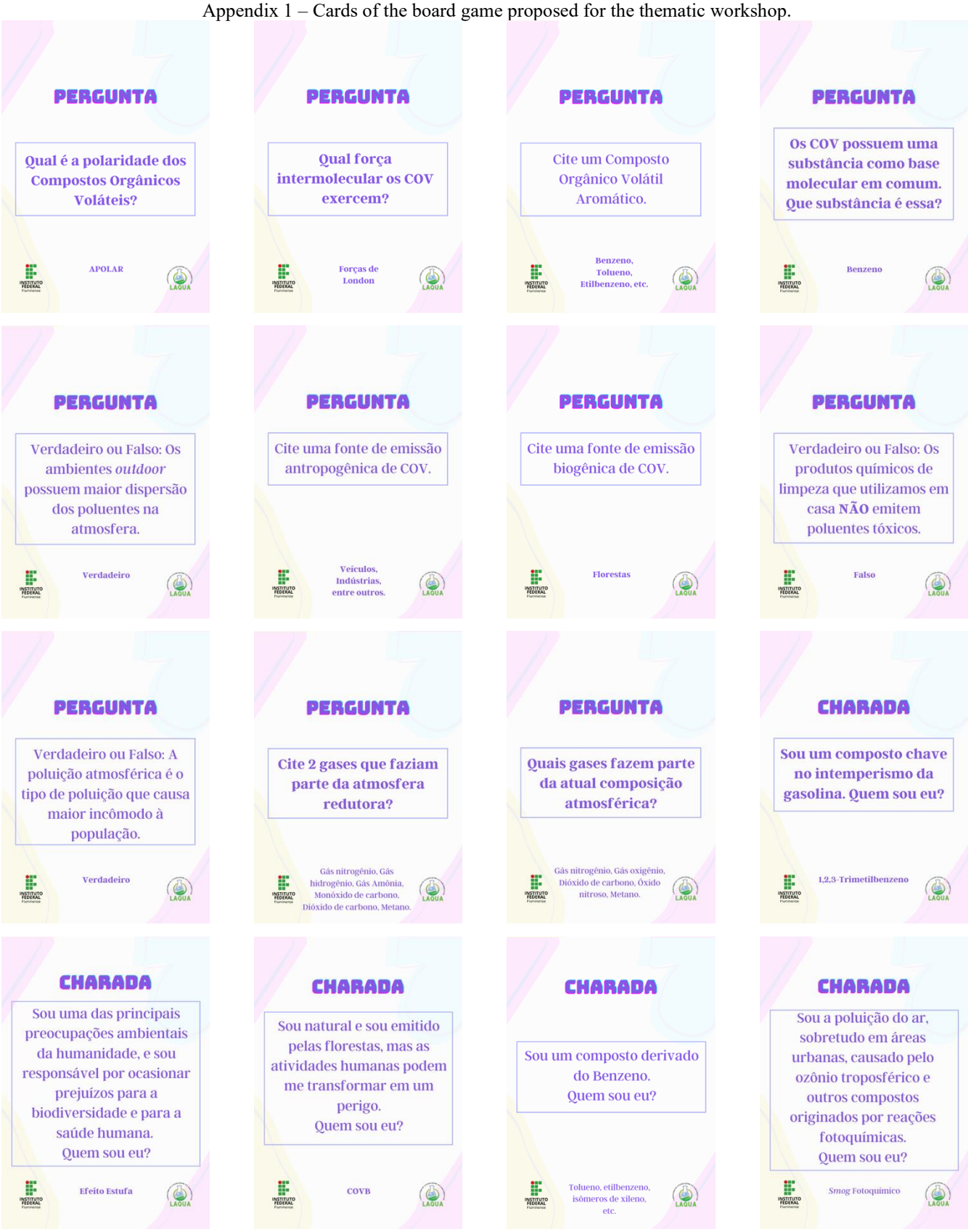
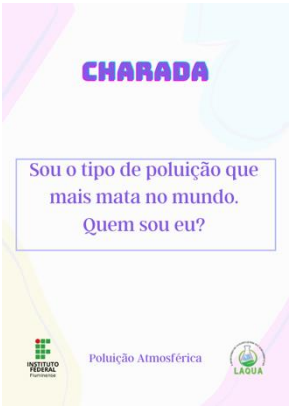
ATTACHMENT

Appendix 1 – Cards of the board game proposed for the thematic workshop.




CHARADA
Sou o tipo de poluição que mais mata no mundo. Quem sou eu?
Poluição Atmosférica
LAQUA