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Aerodynamics and research-based teaching: the perception of club students

ARTICLE

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Abstract
The objective of the work is to analyze the perception of some participants in an activity on aerodynamics in a Science Club. Nine students participated in the meeting, where the principles of aerodynamics were presented through paper airplane models, aiming at the contextualization of theoretical knowledge as well as everyday life (of birds). The qualitative study used Carvalho (2013) as a reference, as did other authors. A Discursive Textual Analysis (Moraes; Galiazzi, 2011) was used to analyze the students' products, especially those of the ship's diaries. As a result, we observed that differentiated and innovative methodologies, such as “Ensino por Investigação”, are promoters of scientific literacy in spaces that do not form teaching. Furthermore, I observed that the students were participatory, expressing what they had understood during the activities. Learning with meaning encourages new concepts to be connected to previous knowledge, creating meaning and significance for learning.

Keywords
Non-formal Spaces. Basic Education. Science Teacher. Science Club. Aerodynamics.

Aerodinâmica e o ensino por investigação: a percepção de alunos clubistas

Resumo
Este trabalho objetivou analisar a percepção de alunos participantes de uma atividade sobre aerodinâmica em um Clube de Ciências. Participaram da ação nove alunos durante um encontro em outubro/2024, em que apresentamos os princípios da aerodinâmica através de modelos de aviões de papel, objetivando a contextualização do conhecimento teórico com o cotidiano (voo das aves). O estudo qualitativo utilizou como referência Carvalho (2013), entre outros. A Análise Textual Discursiva (Moraes; Galiazzi, 2011) foi utilizada nas análises das produções dos alunos, especialmente aquelas dos diários de bordo. Como resultado, observou-se que a utilização de metodologias diferenciadas e inovadoras, como o Ensino por Investigação, são promotoras da alfabetização

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científica em espaços não formais de ensino. Além disso, observou-se que os alunos se mostraram participativos, expressando o que haviam entendido durante as atividades. A aprendizagem com significado favorece que conceitos novos sejam conectados a conhecimentos prévios, trazendo sentido e significância para aprendizagem.
Palavras-chave: Espaços Não Formais. Educação Básica. Ensino de Ciências. Clube de Ciências. Aerodinâmica.

1 Introduction

Teaching Science, in general, has become a major challenge in classroom practice. The lack of interest, combined with the difficulties students face in assimilating scientific content, makes the teacher’s task particularly demanding. These observations highlight the need for reflection on the construction of scientific knowledge in the classroom, in order to overcome the culture of transmitting decontextualized information (Souza; Andrade, 2019).

Specifically, regarding the teaching of Physics, this unfavorable scenario is quite evident (Almeida; Silva, 2015). Classes no longer meet the students’ reality; teachers, in many cases, were not adequately trained to manage overcrowded classrooms; and the teaching resources and methodologies employed are often outdated (Nascimento *et al.*, 2025).

The teaching of airplane aerodynamics, for instance, depending on the methodology and approach adopted, has surprising potential to connect the physical concepts taught in the classroom with students’ real-world experiences, while also linking them to other everyday applications. However, the complexity of the concepts involved often causes students to feel “lost” amid equations and formulas, without understanding the practical application of such knowledge (Almeida; Silva, 2015).

Therefore, it is necessary to discuss and propose teaching strategies that minimize the negative effects of this reality, which increasingly contributes to students’ lack of interest in this subject (Almeida; Amorim; Malheiro, 2020).

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One way Science teachers can spark students' interest in the discipline is by planning their lessons through the perspective of Inquiry-Based Teaching (Malheiro, 2016). Adopting a didactic approach centered on this method means innovating, shifting the focus from mere content transmission to a more active and investigative form of teaching (Barbosa *et al.*, 2021).

The Inquiry-Based Teaching methodology has emerged as a didactic approach in science education, contributing to learning, knowledge construction, and students' scientific literacy. According to Sasseron (2015), this methodology is understood as a process that develops individuals' ability to analyze and evaluate situations based on acquired scientific knowledge, enabling them to make informed decisions.

Carvalho (2013) presents the Investigative Teaching Sequence (ITS) as a proposal that aims to place the student in the role of a scientist, according to an innovative perspective in which teaching and learning occur in a non-linear way. It is based on the assumptions of Piaget's theory of equilibration and knowledge systematization, as well as on Vygotsky's ideas of social interaction and knowledge construction.

The ITS consists of four stages. The first involves presenting a problem to the students and providing them with materials to solve it. The second requires students, working in groups, to search for solutions to the problem. In the third stage, students present their solutions and explain the reasoning that led them to their conclusions. Finally, the fourth stage entails the individual systematization of knowledge, followed by an assessment, usually in written form.

This methodological approach aims at learning through problem situations or puzzles that develop essential cognitive skills across all areas of knowledge, focusing on student learning (Albuquerque *et al.*, 2024). In Inquiry-Based Teaching, the student becomes the protagonist and has degrees of freedom to propose and plan activities, as well as to defend their viewpoints with teachers and peers (Barbosa; Malheiro, 2020).

Breaking away from the often "rigid" and traditional teaching of Physics in formal schooling, with the goal of achieving scientific literacy through an investigative, differentiated, and innovative approach, can be achieved by using non-formal learning

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environments (Almeida; Amorim; Malheiro, 2020; Vasconcellos *et al.*, 2024). These spaces are understood as any environment used for educational purposes that does not conform to the traditional school classroom model. They may be institutional, such as museums, research institutes, and planetariums, or non-institutional, such as theaters, public squares, and cinemas (Jacobucci, 2008).

In these non-formal learning environments, various areas of knowledge, including Physics, can be explored, and among them is aerodynamics. The study of aerodynamics is commonly perceived in everyday life but is rarely addressed in schools and by teachers, due to its abstract nature and reliance on complex mathematical formulas (Moreira, 2021). Science Clubs (Clubes de Ciências – CC) can offer a more dynamic methodology, free from the limitations of rigid and traditional curricula commonly found in schools, ensuring a more empirical learning process and improving the understanding of complex topics such as aerodynamics (Siqueira; Malheiro, 2020).

Science Clubs can become a concrete opportunity for students to engage in playful activities, practicing “doing science” in a light and enjoyable way, while also contributing to the development of more conscious and participatory citizens in relation to the interplay between science, technology, and society (Menezes; Schroeder; Silva, 2012).

As a pedagogical resource, playful activities—such as those in which children build airplanes using sheets of paper—are of great importance in science teaching and learning processes. They serve as necessary and useful exercises, as games and play are indispensable elements for ensuring learning with enjoyment, fostering pleasure in the act of learning, and facilitating pedagogical practices in the classroom (Romera, 2021).

This study presents an analysis of the perceptions of basic education students who participated in an aerodynamics activity in a Science Club in the Northern region of Brazil. The reports recorded in participants’ logbooks, during and after the activity, were analyzed based on Didactic Work Analysis (Análise do Trabalho Didático – ATD). This methodology consists of a three-stage cycle—unitarization, categorization, and communication—that enables the construction of new understandings about the topic studied (Moraes, 2003).

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The ATD has been recurrently used in Science Education research, corresponding to a methodology for analyzing qualitative data and information with the aim of producing new insights into phenomena and discourses (Moraes; Galiazzi, 2011). From this perspective, the ATD draws on phenomenological and hermeneutical principles, which guide the researcher to go beyond what is already known about a phenomenon, through a movement of circles and spirals that aim to transform pre-understandings into expanded understandings (Moraes; Galiazzi, 2011).

The ATD presents the advantage of broadening the understanding of phenomena through the exercise of analyzing the meanings of the selected terms, allowing researchers' pre-understandings to be expanded (Moraes; Galiazzi, 2011). In this way, the perceptions of Science Club members contained in the logbooks will be analyzed, resulting in the authors' understanding of the activity carried out.

2 Methodology

This research adopts a qualitative approach, using Didactic Work Analysis (Análise do Trabalho Didático – ATD), proposed by Moraes and Galiazzi (2011), as an analytical tool. The study was carried out in a Science Club (SC) in the Northern region of Brazil, during a one-day meeting in October 2024.

The SC in question is characterized as a non-formal and interdisciplinary teaching space, aimed at building scientific knowledge through investigative experimentation and the promotion of scientific literacy, understood as the comprehension of the language of science (Vasconcellos *et al.*, 2024). Its objective is to popularize science and technology among Basic Education students, using experiments that simulate natural phenomena from everyday life and foster the understanding of these processes (Malheiro, 2016).

Currently, SC meetings are held biweekly, on Saturday mornings. Occasionally, itinerant activities are organized, in which the team travels to the community to promote the popularization of science in schools or public spaces. The team of monitors is composed of professionals from multidisciplinary backgrounds, including teachers, technicians,

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undergraduate students from different fields, and graduate students (Albuquerque *et al.*, 2023).

The selection of students to participate in the SC begins with an in-person presentation of the project to classes from the final years of Elementary School (8th and 9th grades) and High School in public schools of a municipality in Northern Brazil.

After the dissemination stage in schools, the selection process of club members begins. Students who express interest in participating in the SC go through an open call in which all stages of the registration and selection process are described. Considering that these are underage students, parents and/or guardians of the selected students must authorize their participation in the club's activities by signing two documents: the Free and Informed Consent Form and the Free and Informed Assent Form.

A total of nine (09) students from the 8th and 9th grades of Elementary School, enrolled in public schools and attending the SC, participated in this study, four (04) of them female and five (05) male. To preserve the identity of participants, they were identified as C01 through C09.

The SC meeting was divided into six stages, detailed below:

1. **Icebreaker** – Playful activities were carried out to stimulate participants' engagement in the meeting and to foster a sense of belonging to the group.
2. **Initial diagnosis** – A survey was conducted to assess the prior knowledge that participants brought with them on the topic to be addressed. This step included a word cloud activity using the technological tool *Mentimeter*[1].
3. **Practice** – The theme of the meeting was introduced through a practical activity in which participants were encouraged to build their own paper airplanes. The activity was structured using an Investigative Teaching Sequence (ITS), in accordance with the methodology suggested by Carvalho (2013).

[1] Mentimeter is an online platform that allows the creation of interactive presentations, aiming to engage the audience and ensure that all voices are heard. A tutorial on how to use this tool is available at: https://www.fm.usp.br/cedem/conteudo/tutorial%20mentimenter.pdf Accessed on: Nov. 1, 2024.

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4. **Snack** – The participants took a break for a collective snack offered by the SC monitors.
5. **Socialization** – Presentation and discussion of the results and conclusions obtained from the practical activity. This step included an expository presentation followed by a discussion circle on the activities carried out.
6. **Evaluation** – At the end of the meeting, participants recorded their evaluation of the activity in their logbooks. The evaluation was based on responses to the following questions: *Describe what you thought of today's activity.* and *How would you rate today's meeting?* The rating scale used was: poor, fair, good, and excellent.

The following section details the actions developed with the participating students.

First, a dynamic activity (icebreaker) was conducted with the SC participants to socialize their expectations. Next, using the Mentimeter tool, a survey was carried out through a word cloud in order to verify the prior knowledge that students brought with them on the topic to be addressed. After a brief introduction to the theme, the participants were prompted to answer the following questions: *Why does an airplane fly even though it is made of metal? How do they land or make turns?* After these questions, the students were encouraged to create their own paper airplanes using a single sheet of paper.

For the construction of the paper airplanes, three (03) prototypes were presented (Fig. 1), although students were also free to create their own models. The prototypes used were: the **dart** airplane (1), the **clipper** (2), and the **bat** (3). These models were deliberately selected due to their distinct characteristics. After constructing the models, the production of launchers for these "airplanes," made from paper and elastic bands, was proposed.

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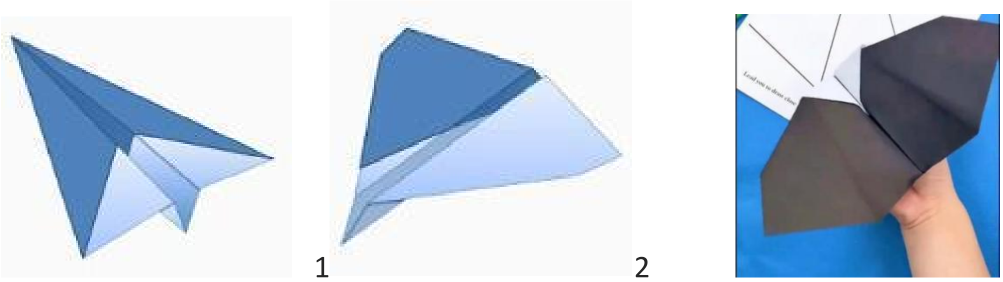
Figure 1 – Airplane prototypes built by SC participants during the activity



1 2 3

Source: Google Images. Available at: https://br.pinterest.com/pin/474566879483021471/. Accessed on: Jan. 2, 2025.

Upon completing the construction of the airplanes, the students were directed to an open area where a competition was proposed. The winner was determined based on the following criteria: distance, height, and flight trajectory of the constructed airplane. Simultaneously, students were prompted to answer other questions such as: *Why does each airplane have a different flight pattern? Which one flies the highest? Which one flies the farthest? And why?*

After the snack break, a discussion circle was conducted, in which students shared their conclusions and hypotheses regarding the activity they had just participated in. Additionally, an expository presentation was delivered using multimedia resources, particularly a notebook and data projector, to provide a more detailed explanation of the activity carried out.

The SC monitors supervised the activities performed by the students and provided scientific explanations of the phenomena involved, such as lift, thrust, drag, and weight—fundamental concepts in aerodynamics. Following this, students were encouraged to exemplify, in their own ways, these forces or other ways of observing the aerodynamic aspects they could perceive before, during, and after constructing and flying the paper airplanes.

At the end of the meeting, students recorded in their logbooks responses to two questions proposed by the monitors: *Describe what you thought of today's activity* and *How would you rate today's meeting?* For the latter, the evaluation followed a four-point scale:

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poor, fair, good, and excellent. The responses provided by the participants constituted the corpus for analysis.

The systematization of the data was based on ATD, starting with unitarization, which involved breaking down the texts into meaningful units. Next, categorization was conducted, a process in which categories were created by grouping elements with similar meanings (Moraes; Galiazzi, 2011).

The inductive method, which is characterized by forming categories based on the units of analysis (Moraes, 2003), was used in building the corpus, resulting in the emergence of categories. Subsequently, hypotheses and arguments were formulated to relate the obtained categories to each other, generating the basic structure of the meta-text.

The meta-text was developed to express the meanings derived from the set of analyzed texts recorded in the logbooks, and its structure was shaped by categories and subcategories resulting from the analysis. The entire textual analysis process is directed toward the construction of the meta-text (Moraes; Galiazzi, 2011).

The final stage involved communicating a meta-text produced from the structure constructed through unitarization and categorization, using description and interpretation to convey the meanings of the analyzed texts (Moraes, 2003).

3 Results and Discussion

The airplane models (Figure 1) built by the students were chosen due to their distinct characteristics. The **dart** model (Figure 1 - 1) flies in a straight line, with minimal wind resistance and slight tilt; the **clipper** model (Figure 1 - 2) exhibits a more curved flight and greater lift; the **bat** model (Figure 1 - 3) has a highly curved flight, travels a short distance, and its lift and drag forces act in such a way that the paper shape resembles the “flapping wings” of a bird.

The models were selected so that students could observe how different shapes produce different flight patterns. In summary, the dart airplane technically travels the

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greatest distance from one point to another, the clipper reaches the highest altitude, and the bat ensures the most sinuous trajectory. The objective of these criteria was for students to perceive the distinct characteristics of each model. The use of launchers for the airplanes aimed to help students understand the differences between the models and the varying thrust forces, which certainly affected the flight.

To emphasize the scientific content related to the phenomena, contextualization was provided with examples from nature, highlighting the different wing shapes of birds: owls, which fly silently; pigeons, which have noisy and irregular flights; and albatrosses, which have the largest wings in the animal kingdom and require more consistent winds to fly.

To further contextualize the experimental practice, the monitor presented additional examples to demonstrate how aerodynamics is applied in the construction of objects such as airplanes and cars, always encouraging participation and guiding students to reach answers through hypotheses and reasoning, thus achieving meaningful and contextualized understanding (Lourenço; Paiva, 2010).

Regarding the activity rating scale of poor, fair, good, and excellent, the results were as follows: eight (08) SC participants rated the activity as excellent, and one (01) participant rated it as good. The categories fair and poor were not mentioned.

In response to the question *Describe what you thought of today's activity*, students were instructed to discuss their perceptions regarding the day's activities. Nine (09) reports in the logbooks were analyzed, and respondents were coded as C01 through C09.

The first cycle of ATD, unitarization, consisted of dividing the analysis corpus, composed of the logbook entries, into smaller excerpts or units of meaning. Next, the researchers conducted a systematic reading of the material to identify possible relationships among the information provided (Moraes; Galiazzi, 2011).

The second ATD cycle, categorization, involved the construction and organization of the elements considered relevant by the researchers, according to the study's objective. This process consisted of classifying initial categories formed by grouping units with similar meanings, as indicated by participants in their logbooks. Categories could be defined a

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priori or after reading the corpus; however, in this study, they emerged throughout the analysis of the records, constituting a posteriori categorization (Moraes; Galiazzi, 2011).

The construction of meta-texts occurred in the third cycle. Meta-texts are responsible for revealing new understandings and knowledge from the research. It was through categorization that the final text was developed, a stage in which theses and hypotheses were tested against the researchers' internal arguments while analyzing the students' written records. These meta-texts are unique, as each researcher has specific characteristics and a different perspective on the information (Moraes; Galiazzi, 2011).

The analysis of students' responses, the Empirical Units, resulted, through the unitarization process, in four Units of Meaning: 1) Satisfaction with the activity; 2) Playful and contextualized activities fostering learning; 3) Reinforcement of prior knowledge; 4) Indication of interest in exploring other themes (Box 2).

These Units were grouped into three initial categories: 1) Perceptions regarding the activity, highlighting the didactic and methodological resources used; 2) Use of subsumer knowledge as a driver of scientific literacy; 3) Stimulation of interest in Science through the proposed activity (Box 1).

Box 1 - Units of Meaning and initial categories systematized from the discourses recorded in the logbooks

Empirical Units	Units of Meaning	Initial Categories
C08: Cool, interesting, and innovative	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C05: Very good. I completely understood; the teacher's explanation is good and understandable	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C07: It was a topic I really enjoyed	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C03: Very good	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used

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C01: I also really liked the airplane experiment	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C06: The activity was very interesting	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C04: I found it very good and interesting	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C09: Excellent, I liked it a lot	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C02: I thought it was cool	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C07: Today we made airplanes and saw how to make them fly and how they could do it. I liked it a lot because they also talked about birds and birds of prey	Satisfaction with the activity	Perceptions regarding the activity, highlighting the didactic and methodological resources used
C03: Today I learned about aerodynamics and tested airplanes of different shapes; there was also a competition	Playful and contextualized activities fostering learning	Playful and contextualized activities fostering learning
C01: I really enjoyed the airplane experiment	Playful and contextualized activities fostering learning	Playful and contextualized activities fostering learning
C06: Learned more about airplanes	Playful and contextualized activities fostering learning	Playful and contextualized activities fostering learning
C04: I have always wanted to see this topic	Use of subsumer knowledge as a driver of scientific literacy	Use of subsumer knowledge as a driver of scientific literacy
C09: Could talk about robotics or chemistry	Use of subsumer knowledge as a driver of scientific literacy	Use of subsumer knowledge as a driver of scientific literacy
C02: I thought it was cool, but I would have liked a topic on astronomy; I would have been very happy	Indication of interest in exploring other themes	Stimulation of interest in Science through the proposed activity

Source: Prepared by the authors (2024).

The development of the Units of Meaning with the Initial Categories resulted in the Intermediate and Final Categories. The Intermediate Categories were: 1) Teaching methods different from the traditional approach; 2) The Science Club (SC) as a non-formal

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teaching space and driver of scientific literacy. The Final Category was: 1) The use of differentiated and innovative methodologies as motivators for scientific literacy in non-formal teaching spaces (Box 2).

Box 2 - Initial, Intermediate, and Final Categories Emerging from ATD

Initial Categories	Intermediate Categories	Final Categories
Perceptions regarding the activity and the didactic and methodological resources used	Teaching methods different from the traditional approach	The use of differentiated and innovative methodologies as motivators for scientific literacy in non-formal teaching spaces
Use of subsumer knowledge as a driver of scientific literacy	The Science Club (SC) as a non-formal teaching space and driver of scientific literacy	
Stimulation of interest in Science through the proposed activity		

Source: Authors (2024).

Based on the analysis of the descriptions and interpretations of the constructed categories and units, a meta-text was produced as a way to express the emerging understandings of the authors.

3.1 Meta-text: innovative methodologies as promoters of scientific literacy

Science Clubs (SC) are important spaces for diversifying pedagogical methodologies for students regarding science dissemination and learning. This non-formal learning environment becomes a space where students can construct scientific knowledge in a playful manner, maintaining interest in scientific activities and their contributions to society (Tomio; Hermann, 2019).

In this sense, SCs, as non-formal spaces for scientific literacy (Vasconcellos *et al.*, 2024), constitute an opportunity for students to engage in activities focused on "doing science." In these spaces, they can develop attitudes and critical thinking while finding conditions to discuss and reflect on scientific, ethical, and moral aspects related to the use of science and technology (Andrade *et al.*, 2023).

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Schmitz and Tomio (2019) state that one of the basic characteristics of an SC is to provide participants with the ability to engage in activities that encourage protagonism and scientific knowledge. This protagonism refers to the prior knowledge mobilized by students during the process of assimilating scientific knowledge in the SC, being directly related to their existing interests and knowledge. It is therefore relevant to correlate this protagonism with David Ausubel's concept of meaningful learning, according to which learning occurs when new information is anchored in preexisting concepts in the individual's cognitive structure (Ausubel, 2000).

Thus, activities proposed by the SC should prioritize and expand students' prior knowledge. This conception is clearly reflected in the discourse of C06, who stated that "*the activity was very interesting because I was able to learn more about airplanes."* The term "more" points to prior knowledge already possessed by the student, which was therefore anchored to the new knowledge acquired during the activity (Ausubel, 2000).

The methodological approach of SCs is closely related to the Inquiry-Based Learning (IBL) approach (Malheiro, 2016). Science Inquiry-Based Learning is a didactic approach strongly recommended worldwide and can be implemented by teachers through activities in which students investigate a proposed problem and attempt to generate hypotheses, solutions, and considerations to address it (Santana; Capecchi; Franzolin, 2018; Malheiro, 2016).

IBL proposals in Brazil have been widely discussed for a long time; however, they are still scarcely implemented in formal teaching spaces. This is largely due to the school curriculum, coupled with infrastructure and class-time limitations, which often prevent educators from going beyond the established content, restricting them to systematic and mechanized teaching (Almeida; Malheiro, 2024).

On the other hand, the SC employs a learning methodology different from conventional teaching. Emphasizing its value as a non-formal learning space, the club recognizes the importance of and implements scientific inquiry in its activities (Benedetti Filho *et al.*, 2020; Lopes *et al.*, 2023).

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The importance and necessity of implementing this differentiated methodological approach are evident in the discourse of C08, who described the activity as innovative, stating that it was "*cool, interesting, and innovative*" and "*I did not expect this topic on aerodynamics, and it was wonderful*." Other terms used by the same participant, such as "interesting" and "wonderful," highlight their perception of the activity and the importance of using innovative, interactive, and non-traditional didactic resources in the scientific literacy process (Andrade *et al.*, 2023). This participant's discourse clearly demonstrates that the use of non-conventional methods is essential to promote meaningful, enjoyable, and engaging learning for students (Ausubel, 2000).

From other perspectives, it is also possible to perceive the didactic and pedagogical potential of the activity, particularly regarding the role of SC teacher-monitors in the scientific literacy process (Coelho; Malheiro, 2019; Barbosa; Malheiro, 2020). This is evidenced in C05's discourse, who described the activity as "*very good. I completely understood; the teacher's explanation is good and understandable*."

Another relevant point refers to the importance of contextualizing content with students' everyday lives. This methodological resource expands possibilities for interaction, not only between disciplines within the same area of knowledge but also between such knowledge and students' realities (Rocha; Malheiro, 2018). This approach seeks to insert disciplinary knowledge into a reality full of experiences, including aspects and issues present in society and students' daily lives.

In summary, contextualizing teaching is bringing formal (scientific) content closer to the knowledge students bring (non-formal, grounded in common sense), so that school content becomes interesting and meaningful to them. In this sense, contextualization invokes areas, domains, or dimensions present in personal, social, and cultural life, mobilizing cognitive skills already acquired (Albuquerque; Freitas; Malheiro, 2024).

This perception is evident in C07's discourse: "*Today we made airplanes and saw how to make them fly and how they could do it. I liked it because they also talked about birds and birds of prey. I really liked this aerodynamics; it was a topic I really enjoyed*." The participant's perception highlights the importance of contextualized teaching in relation to

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their reality and reinforces the importance of prior knowledge in the scientific literacy process (Albuquerque; Freitas; Malheiro, 2024).

The relevance of the aerodynamics activity, from the participants' perspective, can also be measured by the recurrence of the term "*interesting*," reflecting their interest and motivation to participate. This is evidenced in C04's statement: "*I found it very good and interesting. I have always wanted to see this topic."* In this regard, Lourenço and De Paiva (2010) argue that motivation to learn is a relevant factor in the learning process; when motivated, students tend to show enthusiasm and make an effort to complete challenging activities, creating a favorable and dynamic environment that fosters the interest necessary to facilitate learning.

The activity and participants' perceptions also highlighted the importance of applicability and playfulness in the scientific literacy process at the SC (Vasconcellos *et al.*, 2024), demonstrating that playful activities can be used as an alternative to promote learning in Science classes, bringing students closer to scientific knowledge.

Specifically regarding the use of playfulness in the aerodynamics activity, C03's report shows how this approach provides a differential in the learning process, achieving the objective of providing enjoyable and engaging learning: "*Very good, today I learned about aerodynamics, and tested airplanes of different shapes; there was also a competition of airplanes.*"

Teaching spaces need to offer the joy of discovery, surprise, enchantment, amazement, novelty, hands-on experience, playfulness, and pleasure in a harmonious way, through pedagogical interventions that take these characteristics into account. The organization of such activities can occur interdisciplinarily, always considering students' interests, in order to motivate them and effectively promote their educational development (Rocha; Malheiro, 2020).

The analyzed discourses highlighted and reinforced the relevance of non-formal teaching spaces as drivers of scientific literacy. These spaces generate discourse that guides and suggests new Science topics, revealing interest in other areas and

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simultaneously contributing to the promotion, consolidation, and dissemination of scientific knowledge (Silva; Cabral; Malheiro, 2020).

Non-formal educational spaces allow for the experimentation and development of other types of experiences beyond those experienced in the classroom, which is highly important because it facilitates improvements in teaching and learning processes (Barbosa *et al.*, 2021).

A non-formal learning space such as the SC provides students with protagonism and flexibility, which they often do not have in conventional classrooms. These factors enable students to develop a more fruitful scientific interest and engage with a variety of Science topics.

This assumption is evident in the participants' statements. C09: "*Excellent, I liked it a lot; it could be about robotics or chemistry.*" C02: "*I thought it was cool, but I would have liked a topic on astronomy; I would have been very happy.*" These statements indicate curiosity, motivation, and interest in continuing to explore scientific knowledge.

Thus, the aerodynamics activity at the SC proved productive and generated interest among participants, successfully achieving its goal of promoting scientific literacy through inquiry-based activities and the use of innovative methodologies in a non-formal learning space (Silva; Cabral; Malheiro, 2020).

4 Final considerations

The main contribution of this study lies in the idea that the use of scientific inquiry, playfulness, and active and innovative methodologies—particularly Inquiry-Based Learning—served, in addition to promoting enjoyment, to provide meaningful learning and stimulate students' interest in the topic addressed. These approaches contributed significantly to the development of skills proposed by official documents, especially the Brazilian National Common Curricular Base (BNCC). Furthermore, the relevance of non-formal learning spaces in this process is evident.

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The research also demonstrates the need to deepen discussions regarding the break from traditional teaching models, since, as evidenced in the participants' discourses, it is possible to observe the benefits of the methodology used in the activity for promoting scientific literacy. This approach moves away from mechanical learning practices and aligns with Freirean literacy, understood as an attitude of creation and recreation that allows the individual to influence their social context.

Another point to consider is the potential for democratization and dissemination of scientific knowledge provided by Science Clubs. In these spaces, discussions about scientific concepts are assimilated and spread to other contexts, allowing knowledge not to remain restricted but to circulate within the community—a process of utmost relevance, especially in light of recent attacks on science fueled by the spread of fake news.

It is also important to highlight that the analyses were conducted exclusively using Discursive Textual Analysis (DTA), a methodology predominantly developed in Brazil. The cycle of unitarization, categorization, and communication proposed by DTA allows, through the immersion required in the process and the theoretical knowledge added by the researcher, for the emergence of original and meaningful results.

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To the Science Club…

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