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SCIENTIFIC LITERACY AND ENVIRONMENTAL AWARENESS: EXPLORING JATAÍ BEES IN A SCIENCE EXHIBITION

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ABSTRACT

This article is an excerpt from a doctoral research carried out in the Graduate Program in Agricultural Sciences of the Federal Institute of Goiás, Rio Verde Campus, whose general objective was to promote the popularization of science and develop a methodology based on scientific literacy, integrating basic education with higher education in the area of Agricultural Sciences. The main focus of the research is on food production in vertical farming systems, with an emphasis on the use of light quality and pollination by meliponas. The research involved scientific popularization activities centered on the study of Jataí bees (Tetragonisca angustula), with educational actions carried out with 70 basic education students. In this excerpt, whose objective is to analyze the impacts of the science fair on the promotion of literacy and environmental education through the study of Jataí bees (T. angustula), data regarding pedagogical intervention practices will be presented, with the elaboration of an action plan that included activities in the classroom, in the Complex of Laboratories in Plant Biotechnology of IF Goiano and in a science fair. These actions addressed the biology, social organization and ecological importance of Jataí bees, with an emphasis on the role of these bees in pollination and the preservation of ecosystems, as well as the relevance of their conservation for environmental sustainability. The data

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collected indicated significant impacts on the perception of students. After carrying out the activities, 78% of the participants reported an increase in interest in science, while 95% recognized the importance of preserving Jataí bees for environmental balance. Additionally, 96.7% highlighted the role of these bees in pollination and food production. The actions of the survey were evaluated as highly relevant by 76.7% of the students, who considered the theme essential for contemporary society. It was concluded that the actions of scientific popularization, carried out both in the classroom and in the laboratories and at the science fair, contributed to awaken the interest of students in science and promote their environmental awareness. This excerpt reinforces the importance of pedagogical practices that connect students to scientific and sustainability issues.

Keywords: Scientific Initiation. Science Fair. Jataí bees.

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INTRODUCTION

Contemporary society is experiencing rapid technological, scientific, social and environmental transformations, and it is necessary for students/citizens to be prepared to act actively in this globalized society. In this scenario, scientific literacy in basic education is essential to form critical citizens, capable of understanding and participating in discussions about scientific issues that impact society. By developing skills such as critical thinking, problem-solving, and data interpretation, students are prepared to deal with everyday challenges and make informed decisions. In addition, this practice stimulates curiosity and interest in science, contributing to the formation of a more innovative, sustainable society that is aware of its role in global development from an early age (MATOSO *et al.*, 2024).

For Marandino *et al*. (2018), scientific literacy transcends the mere memorization of scientific concepts. It is about preparing students to understand and critically interpret the world around them, stimulating reflective and investigative thinking. In turn, Sasseron (2015, 2018) contributes by highlighting the importance of scientific literacy and teaching by inquiry. In this context, scientific literacy involves the contact of students with knowledge produced by scientific studies, as well as the understanding of the relationships and constraints that affect the construction of knowledge.

> Teaching by investigation and argumentation, on the other hand, fulfill a double function in our research: at the same time that they represent modalities of interaction worked for the development of Scientific Literacy in the classroom, they constitute forms of study of the data from our research. (SASSERON, 2018, p. 51).

For Batista (2018), scientific literacy is a fundamental element to promote scientific initiation among basic education students, serving as a starting point for the development of investigative thinking and the understanding of scientific methods. Through scientific literacy, in addition to arousing curiosity and interest in scientific topics, it is possible to incorporate environmental education into the curriculum, sensitizing students to ecological and sustainable issues.

It must be taken into account that environmental preservation and biodiversity are increasingly threatened by human action, making it urgent to implement educational initiatives that promote awareness and sustainable practices. According to Santos and Carvalho (2023), environmental education is an essential tool to integrate scientific knowledge into practice, helping to form citizens committed to sustainability.

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Nevertheless, it is relevant to highlight that, in most high schools and elementary schools, biology and science classes, in the way they are taught, do not favor the student to develop effective learning of the contents presented. The passivity of students is a reality that may be caused by a lack of interest in curricular components that, for the most part, have no relation to daily life or their concerns as students (CASTRO and GOLDSCHMIDT, 2016).

According to PISA (*Programme for International Student Assessment*) data, despite a significant improvement in student skills and competencies in science, since the 2006 assessments, less than 40% of Brazilian students aged 15 were able to use the knowledge acquired in school to observe, describe and explain real phenomena or formulate evidence-based conclusions (OECD, 2012).

One of the reasons for this learning gap lies in the traditional, decontextualized and non-participatory methodologies of teaching in schools. Teaching is predominantly theoretical and descriptive and science is presented as a set of definitions, principles and ready-made laws, absolute truths, which are found in books. The scarce participation of students in the construction of this knowledge, whether through investigative activities or other dynamics where dialogue is present, means a reduced opportunity to understand the origin and usefulness of such scientific propositions (SASSERON and CARVALHO, 2011).

This justifies the importance of this study, which explores the scientific literacy and ecological relevance of Jataí bees (*T. angustula*), with an emphasis on the role of these bees in pollination and the preservation of ecosystems. However, they are still undervalued due to the population's lack of knowledge, which limits efforts to preserve them. It has been believed, for at least a century, that stingless bees have drawn the attention not only of farmers, but also of the scientific community (Silva, Da Paz, 2012). The authors argue that the conservation of stingless bees should not be restricted to parks and reserves, but should also benefit from technological advances. In addition, they point to the need for new studies on these bees in different areas of knowledge.

Thus, the process of scientific literacy involving themes such as bees and their role in the preservation of ecosystems, with presentation at a science fair, provides opportunities for the development of investigative skills for basic education students. Nunes *et al.* (2017), assess that the holding of science fairs points to beneficial changes in students and teachers, changes that were evidenced during and from the research processes caused by participation in such events, such as the development of creativity

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and students' inventive and investigative capacities. According to the aforementioned authors, science fairs enable everyone involved to learn and socialize their knowledge in a critical, autonomous and pleasurable way.

This type of approach meets what today's society needs, namely, differentiated learning with the development of knowledge and attitudes that promote citizenship education. In this sense, Adams *et al*. (2020) analyze that science fairs are relevant alternatives for the promotion of the formation of critical citizens and for the construction of knowledge by students.

Thus, the approach of students to scientific knowledge, through an active appropriation that interconnects theory and practice, can overcome the character of mere transmission of content in Science classes. In these classes, students participate in innovative and autonomous experiences, whose objective is to provide investigative experiences (ADAMS *et al*., 2020).

In view of the above, this research excerpt aims to analyze the impacts of the science fair on the promotion of literacy and environmental education, through the study of Jataí bees (*T. angustula*). It seeks to highlight its ecological importance, its role in pollination and the preservation of ecosystems, as well as to raise awareness of the need for sustainable practices in the conservation of biodiversity.

METHODOLOGY

This research was approved by the Ethics Committee, through Opinion No. 5,282,771, and funded by Call No. 27/2021 CNPq/A.B.E.L.H.A – Line 3: Pollination services in crops of agronomic interest – Process No. 401535/2022-3. Among the scientific aspects addressed by the research are the quality of light and the importance of pollination by stingless bees, of the Jatai species (*T. angustula*), aiming at the popularization of science. Additionally, the laboratory's vertical farming structure was developed via funding received for the project approved by the FINEP/FAPEG Call No. 07/2019 - Tecnova II – Process No. 202010267000346.

It is a research with a qualitative approach that focuses on the deep understanding and interpretation of the phenomena studied, exploring the complexity and richness of social, cultural and individual contexts. One of the most relevant aspects of qualitative research is the use of methods and techniques aimed at data collection and analysis. Such methods include interviews, participant observation, document analysis and content

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analysis. These methods enable researchers to explore the experiences, perceptions, and meanings of the participants, in order to build a deeper and more contextualized knowledge about the facts studied (CAMARGO *et al*., 2021).

In the context of research with a qualitative approach, the principles of action research were used, which involves the active participation of researchers and subjects. In this type of research, in addition to observing and analyzing the situation, researchers also act to transform it. Researchers are encouraged to discuss their own hypotheses in order to ensure the validity and relevance of the results achieved (CAMARGO *et al*., 2021).

LOCATION, PERIOD, AND PATHS OF DATA COLLECTION

The data used in this section of the survey were collected in 2023, between the months of February and June. 70 students from the 8th and 9th grades of elementary school participated in the research, who were divided into 10 groups. Each group presented the results of their research, built during the semester, at the science fair that took place in a full-time school, located in the State of Goiás. The research was developed after practical and theoretical classes on Jataí bees, vertical cultivation and the importance of artificial light in food cultivation. In this study, we will focus on the works on Jataí bees, developed by the students.

The central theme of the science fair, for these students, was the study of Jataí bees (*T. angustula*), highlighting their biology, social organization and ecological importance. Initially, classes were held, during the scientific initiation schedule, on Jataí bees and their ecological relevance, addressing topics such as pollination, biodiversity and sustainability. This stage aimed to offer a context to the students and awaken their interest in the theme. Then, investigative activities were carried out, such as observation through videos and photographs, of the Jataí bee colonies, where students analyzed aspects such as behavior, social organization and interaction with the environment. Group discussions were also held to raise hypotheses and share perceptions.

The production of materials for the science fair was another important step. The students, organized in groups, created posters, models, multimedia presentations and reports that synthesized the knowledge acquired. During the event, the students took on the role of scientists, presenting the information collected to the public and discussing the importance of the conservation of Jataí bees for environmental sustainability and the preservation of ecosystems.

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DATA COLLECTION PROCEDURES AND INSTRUMENTS

In the collection of data for the production of this excerpt of the research, observation procedures were used with registration in a field diary, photographs to record the activities carried out and a questionnaire applied at the end of the science fair, in order to analyze the development of the activities and evaluate the students' understanding of the impact of the project.

DATA ANALYSIS

Data analysis was performed based on Bardin's (2013) approach, using content analysis as a central method. This procedure involved the systematic categorization and interpretation of the collected data, seeking to identify patterns, relationships and meanings in the analyzed contents. Initially, a floating reading was done, to create familiarity with the material. Next, thematic categories were defined, elaborated from the objectives of the study. Subsequently, the data were codified, organized and interpreted, which allowed the extraction of relevant information and the conclusions were based with methodological rigor and analytical clarity. Added to this is the descriptive statistical analysis of the data obtained through the questionnaire applied after the science fair. Excel® graphs were prepared for the presentation of these results. This analysis allowed us to collect relevant information about the participants' perceptions of the project presented, highlighting the most impactful aspects and contributions to environmental awareness and interest in science.

SCIENCE FAIR: CULMINATION OF RESEARCH AND SCIENTIFIC LITERACY IN ACTION

In this topic, we will highlight the results of the development of the science fair and its impact on the students' gaze. The science fair was the result of research actions worked during a semester, as mentioned, being, therefore, the culmination of the study and investigation process developed by the students during the research.

For the fair, each group of students was in charge of deepening a specific aspect related to the study of Jataí bees (*T. angustula*), with the aim of exploring their biology, ecology and environmental relevance. The issues addressed included morphological and behavioral characteristics, the role of bees in pollination and in the maintenance of biodiversity, their social organization within the hive, the component products of their

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activity, such as honey and propolis, and their economic and therapeutic relevance. In addition, the groups investigated sustainable management and conservation practices of hives, highlighting the importance of preserving these bees as essential agents for the balance of ecosystems. Through this division of responsibilities, the study allowed for an interdisciplinary and detailed approach, connecting scientific, ecological and social aspects about Jataí bees (Figure 01).

FIGURE 01: Organization of the room for presentation.

Source: The authors.

The students presented to the visitors of the science fair the biological and behavioral characteristics of the Jataí bees (*T. angustula*), addressing aspects such as size, coloration, absence of stingers and social behavior.

Thus, during the participation in the science fair, it was possible to observe that the students had the opportunity to present their work, the result of a process in which they searched, gathered and interpreted information to share it with the public. These activities not only promoted the active and effective construction of knowledge, but also encouraged the connection of this learning with its practical applications in daily life, as pointed out by Nunes *et al*. (2017). In addition, the students gave explanations about the geographic regions where these bees are found, highlighting their wide distribution in tropical and subtropical areas of Latin America, and the environmental conditions suitable for their survival (Figure 02).

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FIGURE 02: Characteristics of Jataí Bees.

Source: The authors.

During the presentation, the students detailed the pollination process carried out by Jataí bees, explaining how they transfer pollen from one flower to another, promoting fertilization and the formation of fruits and seeds. They highlighted the relevance of this ecosystem process for the maintenance of biodiversity and agricultural production. In addition, they identified the plant species frequently pollinated by these bees, emphasizing their relationship with native and cultivated plants (Figure 03).

FIGURE 03: Pollination of Jataí Bees.

Source: The authors.

In the process of acting as child researchers, the students explained about the social structure of Jataí bees, explaining the functional hierarchy within the hive. They addressed the role of workers, drones and the queen bee. They also explained how this social organization contributes to the efficiency and survival of the colony (Figure 04).

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FIGURE 04: Organization of Jataí Bees in the Hive

Source: The authors.

Signaling theoretical and practical knowledge of the subject, the students referred to the main products of Jataí bees, such as honey and propolis. They highlighted the nutritional quality and therapeutic properties of these products, highlighting their use in food and alternative medicine (Figure 05).

FIGURE 05: Products Manufactured by Jataí Bees.

Source: The authors.

Another aspect explored was the ecological importance of Jataí bees for the balance of ecosystems. The students emphasized the role of these bees in pollinating native plants and maintaining genetic diversity. They also highlighted the main threats to bee survival, such as deforestation, pesticide use, and climate change, and discussed bee conservation (Figure 06).

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FIGURE 06: Ecological Importance and Preservation of Jataí Bees.

Source: The authors.

In addition to information about the social structure of bees, pollination and ecological importance, the students addressed management techniques and sustainable cultivation of Jataí bees. They emphasized that the cultivation of these bees can be a viable alternative for the preservation of the species and its products, in addition to promoting environmental education and awareness about the importance of biodiversity (Figure 07).

FIGURE 07: Cultivation of Jataí Bees

Source: The authors.

In all the activities developed, whether in the preparation, in the literature research, in the collection and analysis of data, or on the day of the science fair, it was possible to verify the importance of these activities for the development of research skills and scientific literacy of students. By seeking, organizing, and presenting information, students exercise critical thinking, investigation, and problem-solving. This process allows science to cease to

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be abstract knowledge, becoming an everyday practice connected to the real world. In addition to promoting the development of learning, science fairs promote the participation of students, who come into contact with the community and with various areas of knowledge. In these activities, students are not restricted to acquiring scientific knowledge, but are also socially, environmentally and morally formed as a consequence of this experience (MEZZARI *et al.*, 2009). Also, Hartmann and Zimmermann (2009) contribute to this analysis by stating that participation in science fairs is, therefore, the culmination of a process of study, investigation and production that aims at the scientific education of students.

THE IMPACTS OF THE SCIENCE FAIR ON THE STUDENTS' EYES

To evaluate the impact of the science fair, as mentioned, students were asked to answer a questionnaire regarding the work and research developed on Jataí bees, in order to identify their perceptions about the scientific initiation activities experienced by them.

Question 01 asked: Do you believe that participating in the science fair on the theme of bees contributed to your interest in science (Figure 8).

FIGURE 08: Question 01.

Source: The authors.

As can be seen in the graph, 41.7% of the students stated that participation in scientific literacy actions significantly increased their interest, while 36.7% stated that there was a moderate increase. Another 10% declared that they already had a high interest in science before the event, 8% stated that the actions did not make a difference in this aspect, and 3.6% mentioned that they had no interest in the area. These data indicate that, for most of the participants, the fair played a positive role in expanding scientific interest.

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Question 02 asked: In your opinion, what was the impact of the research actions at the science fair on raising awareness about the preservation of bees (Figure 09)?

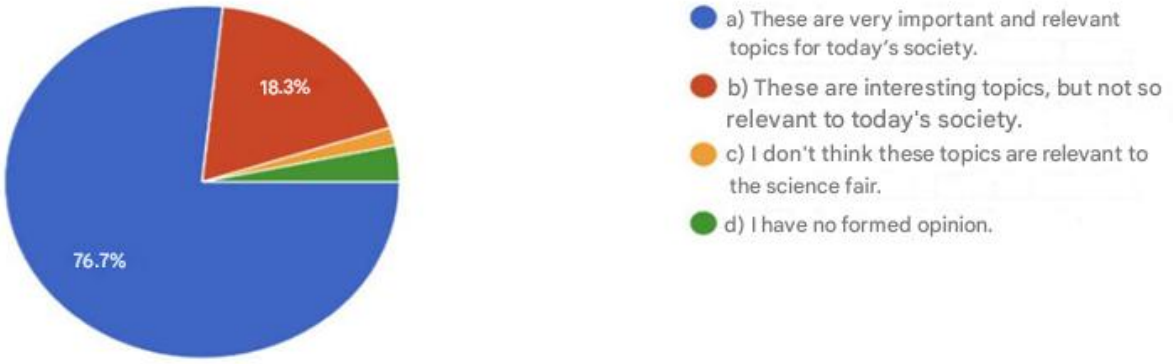
FIGURE 09: Question 02.

Source: The authors.

Regarding the awareness about the preservation of Jataí bees, 58.3% of the students believe that the actions of the research carried out by them aroused awareness and interest, both among the participants and among the visitors of the fair. Another 35% considered that the surveys carried out by them promoted some level of awareness, 5% evaluated the impact as low, and 1.7% did not know how to give an opinion on the subject. These results demonstrate that the students' actions were able to reach the public, promoting reflections on the environmental importance of bees.

Question 03 asked: How do you evaluate the importance of the approach to bees in the science fair (Figure 10)?

FIGURE 10: Question 03.



Source: The authors.

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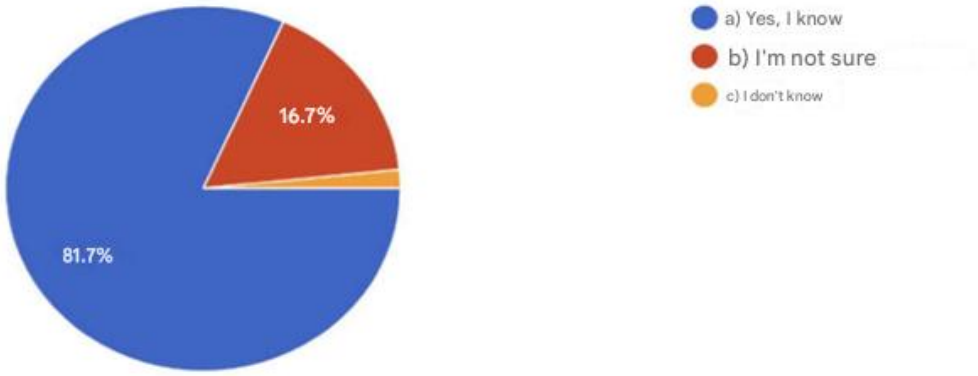
Regarding the relevance of the topic addressed, 76.7% of the students considered that discussing Jataí bees is very important and relevant to today's society, while 18.3% found the topic interesting, but not so relevant. Only 1% evaluated the topic as irrelevant, and 5% declared that they had no opinion. This predominance of positive evaluations reinforces the relevance of the theme for educational and scientific initiatives.

Question 04 asked: Do you know what the role of Jataí bees is in the ecosystem (Figure 11)?

FIGURE 11: Question 04.

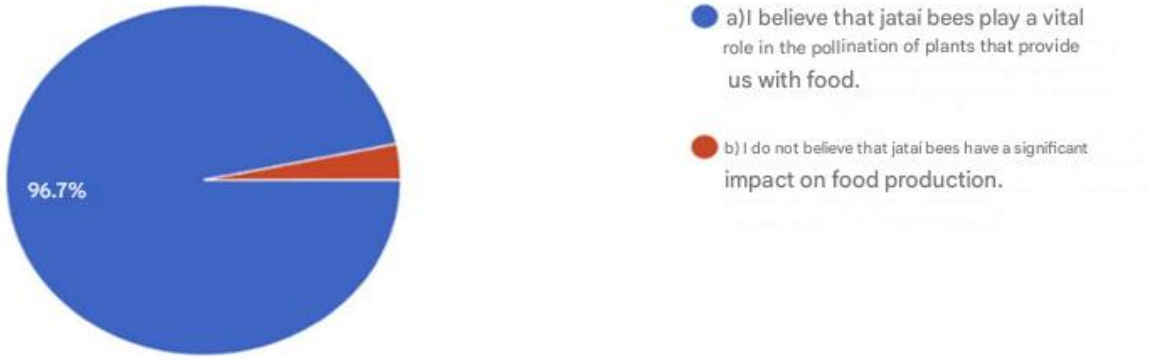


Source: The authors.

When asked about the role of Jataí bees in the ecosystem, 81.7% of the participants demonstrated knowledge by answering that they knew what the function of these bees is, 16.7% were not sure and 1.6% said they did not know.

Question 05 asked: What is your opinion about the relationship between Jataí bees and food production (Figure 12)?

FIGURE 12: Question 05.



Source: The authors.

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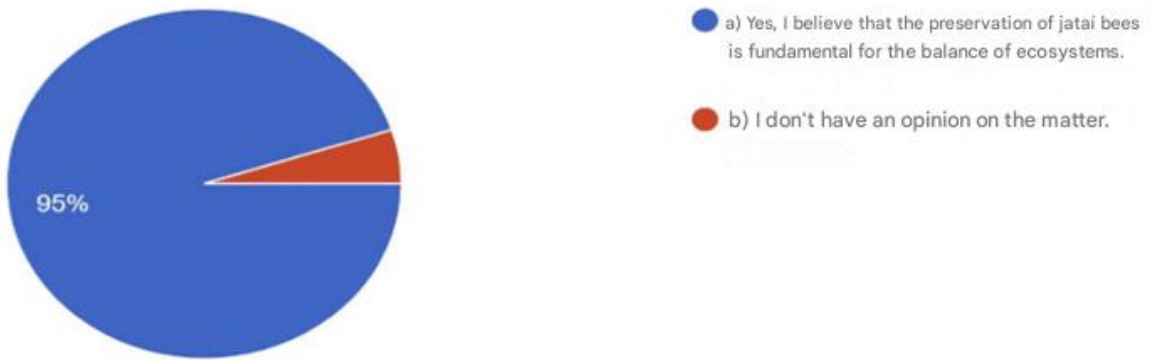
When questioned, 96.7% of respondents stated that they believe that Jataí bees play a vital role in pollinating plants that provide food, while only 3.3% considered that their impact on food production is not significant.

Question 06 asked: Do you believe that the preservation of Jataí bees is important for the conservation of the environment (Figure 13)?

FIGURE 13: Question 06



Source: The authors.

Finally, the preservation of Jataí bees was extremely recognized as fundamental for environmental conservation, with 95% of students agreeing with their importance for the balance of ecosystems and only 5% reporting not having an opinion. In general, the results of the survey show that the science fair contributed to increasing students' interest in science and promoting awareness about the ecological relevance of Jataí bees, reinforcing the importance of innovative educational initiatives for sustainability and environmental preservation.

In a similar case study, Tavares *et al.* (2016) realized that the theme "Stingless bees" and the work methodology used proved to be efficient. The authors stated that educational activities in non-formal spaces are well accepted by students and reinforce the need for basic education teachers to plan their classes, as far as possible, contemplating activities that can be developed in these spaces.

It is notorious that the activities involving scientific initiation with Jatai bees contributed to making students protagonists of their own learning, encouraging research, critical reflection, knowledge production and reflection on environmental issues. Adams (2020) contributes by reporting that, from a methodological point of view, science fairs can provide the stimulus to deepen studies and the search for new knowledge, in addition to having the ability to foster discussion on social and environmental problems.

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Thus, it was observed that one way to make this learning more interesting and motivating was to employ biological models with which students could learn basic concepts, observing the behavior of living organisms, such as bees. The possibility of seeing and learning from these insects could also awaken ecological awareness and environmental preservation. According to Prates *et al.* (2024), the connection between learning and real problems stimulates critical thinking and the formation of citizens capable of facing the ecological challenges of the present and the future.

Oliveira (2017) also contributes to this reflection by emphasizing that investigative practices arouse students' interest in the scientific method while developing skills such as analysis, questioning, and argumentation. The study of Jataí bees, due to its interdisciplinary and investigative nature, allowed students to understand the essential role of these instructions in maintaining biodiversity and food production, as they explored practical solutions for environmental preservation.

Another significant aspect of the pedagogical practices developed was the integration of scientific literacy with environmental education, which is defended in the literature as a necessity to form citizens aware of and engaged with sustainability. According to Santos and Carvalho (2022), environmental education, when incorporated into pedagogical practices, promotes awareness of environmental issues and stimulates changes in behavior. In the case of Jataí bees, the project can contribute to integrating concepts of ecology and sustainability, highlighting the relevance of bees to ecosystems and sensitizing participants to the importance of their conservation.

In this way, the study of Jataí bees, during the science fair, exemplifies contemporary and effective pedagogical practices that combined scientific literacy and environmental education. These approaches, based on studies by recent authors, show that contextualized educational projects have great potential to transform students' relationship with science, encouraging critical thinking and environmental awareness.

CONCLUSION

The study on Jataí bees (*T. angustula*), developed and presented at a science fair, proved to be an important didactic alternative to raise environmental awareness among the participants. During all stages, from the preparation to the culmination of the fair, the change in the students' perception of environmental issues became evident, as well as the deepening of their understanding of the importance of bees for the balance of ecosystems.

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In addition, the opportunity to share the scientific experience with visitors allowed students to demonstrate their learning by addressing the topics studied and to clearly answer the questions asked by the audience.

The results of the research show that the thematic approach not only broadened the students' interest in science, but also fostered reflections on the preservation of bees and their essential role in biodiversity. In the questionnaire applied after participating in the actions, most participants highlighted the relevance of Jataí bees for pollination and the maintenance of ecosystems, as well as their direct influence on food production. These findings reinforce the importance of educational initiatives that connect scientific literacy to environmental issues, stimulating critical thinking and promoting the appreciation of sustainability.

Thus, in addition to raising environmental awareness, the study contributed significantly to the scientific literacy of students, providing a practical experience of the scientific method. Active participation in research, from the formulation of hypotheses to the communication of results, made it possible to construct knowledge in an autonomous and contextualized way. In this way, students not only acquired new knowledge about Jataí bees, but also developed essential skills to interpret and analyze scientific phenomena, strengthening their ability to make evidence-based decisions.

Finally, the results indicate that the science fair demonstrated its role not only as a learning space, but also as a transformative experience, expanding the involvement and protagonism of basic education students in scientific and environmental themes. The study of Jataí bees served as an instrument for raising awareness and developing scientific literacy, highlighting the relevance of pedagogical practices that integrate science and the environment in the formation of a generation that is more aware and committed to environmental preservation.

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