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Educational experiences for Elementary School students learning about the characteristics and importance of insects

Vivências pedagógicas para o aprendizado de estudantes do Ensino Fundamental sobre as características e importância dos insetos

Experiencias pedagógicas para el aprendizaje de los alumnos de Primaria sobre las características e importancia de los insectos

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Abstract
This study objective to evaluate whether using alternative educational practices increases students knowledge using the topic "The importance of insects in the environment" as an example. The study was conducted in two 5th grade classes of a public school in Teixeira de Freitas, state of Bahia, Brazil, from May to September 2016. To verify the effectiveness of the practices carried out, a questionnaire was used to evaluate the perceptions of the students on the topic addressed before and after the implementation of the educational activities. The data obtained from the questionnaire (before and after the activities) was subjected to frequency analysis and was compared using a test of proportions (binomial test) at $P < 0.05$. In general, it was found that before the interventions, students knew little about the scientific and ecological importance of insects, could not effectively distinguish them from other arthropods and animal classes, and often held negative beliefs about these organisms. However, after the interventions, the students' ability to recognize insects, as well as their concepts and behaviors related to insects, changed significantly. The results demonstrate the effectiveness and importance of alternative teaching methods that allow students to have more contact with the subject matter. Also, how significant is to make them active subjects in the teaching-learning process, facilitating the construction of knowledge.
Keywords: Insects; Education; Teaching methods; Practical lessons; Teaching.

Resumo
O objetivo deste estudo foi avaliar se o uso de práticas educacionais alternativas aumenta o conhecimento dos estudantes usando como exemplo o tópico "A importância dos insetos no meio ambiente". O estudo foi realizado em duas turmas da 5ª série de uma escola pública em Teixeira de Freitas, estado da Bahia, Brasil, de maio a setembro de 2020. Para verificar a eficácia das práticas realizadas, foi utilizado um questionário para avaliar as percepções dos alunos sobre o tema abordado, antes e depois da implementação das atividades educativas. Os dados obtidos a partir

do questionário (antes e depois das atividades) foram submetidos à análise de frequência e foram comparados utilizando um teste de proporções (teste binomial) em $P < 0,05$. Em geral, verificou-se que antes das intervenções, os estudantes sabiam pouco sobre a importância científica e ecológica dos insetos, não conseguiam distingui-los efetivamente de outros artrópodes e classes de animais, e muitas vezes tinham percepções negativas sobre estes organismos. Entretanto, após as intervenções, a capacidade dos estudantes de reconhecer os insetos, assim como seus conceitos e comportamentos relacionados aos insetos, mudou significativamente. Os resultados demonstram a eficácia e a importância de métodos de ensino alternativos que permitem que os alunos tenham mais contato com o assunto em questão. Além disso, quão significativo é torná-los sujeitos ativos no processo de ensino-aprendizagem, facilitando a construção do conhecimento.
Palavras-chave: Insetos; Educação; Métodos de ensino; Aulas práticas; Ensino.

Resumen
El objetivo de este estudio fue evaluar si el uso de prácticas educativas alternativas aumenta los conocimientos de los estudiantes utilizando como ejemplo el tema "La importancia de los insectos en el medio ambiente". El estudio se realizó en dos clases de 5º grado de una escuela pública de Teixeira de Freitas, estado de Bahía, Brasil, de mayo a septiembre de 2020. Para verificar la eficacia de las prácticas realizadas, se utilizó un cuestionario para evaluar las percepciones de los alumnos sobre el tema abordado antes y después de la implementación de las actividades educativas. Los datos obtenidos del cuestionario (antes y después de las actividades) se sometieron a un análisis de frecuencias y se compararon mediante una prueba de proporciones (test binomial) a $P < 0,05$. En general, se comprobó que, antes de las intervenciones, los alumnos sabían poco sobre la importancia científica y ecológica de los insectos, no podían distinguirlos eficazmente de otras clases de artrópodos y animales, y a menudo tenían creencias negativas sobre estos organismos. Sin embargo, después de las intervenciones, la capacidad de los alumnos para reconocer a los insectos, así como sus conceptos y comportamientos relacionados con ellos, cambiaron significativamente. Los resultados demuestran la eficacia e importancia de los métodos de enseñanza alternativos que permiten a los alumnos tener un mayor contacto con la materia. También, lo significativo que es convertirlos en sujetos activos en el proceso de enseñanza-aprendizaje, facilitando la construcción del conocimiento.
Palabras clave: Insectos; Educación; Métodos de enseñanza; Lecciones prácticas; Enseñanza.

1. Introduction

The educational process is composed of different elements, such as the curriculum, the students learning rhythm, the relationships between students and teachers, the models and didactic materials used, the pedagogical strategies for teaching, and the assessment of learning. In recent years, however, we have noticed that much of the science education have been focusing on the delivery of content through expository teaching, in which the student is no longer the focus of the teaching-learning process but is merely a receiver of information. This form of teaching does not always achieve the expected goals and makes it difficult for students to understand the content, which can foster their demotivation for the topic being studied (Nascimento *et al*., 2022). Therefore, researchers in the field of science education have worked to develop alternatives and/or didactic strategies, such as didactic games, experiments, the use of equipment, hands-on lessons, and other methods that help teachers in their pedagogical practice (Nicola & Paniz, 2016; Leão *et al.*, 2018; Carvalho *et al*., 2024). The use of these alternatives and strategies can make science lessons more engaging, dynamic, enjoyable, and fun, thus helping students learn better.

Although the textbook is a very important tool during technological progress, new didactic ways or teaching are needed. One of the means that are frequently used in science classes are games since they allow and facilitate the students' understanding and association with the subject. However, in most Brazilian public schools, there is a lack of teaching materials for hands-on teaching and laboratories (Matos *et al.*, 2009). Given the difficulties observed, some researchers in science education have developed alternative didactic and pedagogical materials to provide teachers with tools for their pedagogical practice. For example, it has been shown that by using inexpensive materials from everyday life, it is possible to create more engaging and motivating lessons in which students are involved in building their own knowledge (Souza *et al.*, 2009). Therefore, the development and use of activities of this type are important not only for teaching but also for understanding the

concepts and processes inherent in living things and for environmental awareness regarding the different organisms found in terrestrial ecosystems.

Several studies have shown that the conceptions, representations, ideas, and images that shape people's biological knowledge are still far from this ideal. For example, science classes in Brazilian schools generally teach contents about animals and plants which has little to do with the students' immediate environment, and that is outside of a context in which students personally live or that populates their imaginations (Wortmann *et al.*, 1997). Especially in the case of invertebrates such as insects, it is important that the teaching is not limited to content only related to internal and external morphology, but make it possible to students to approach, experience and apply the concepts learned (ecological importance, habitat, niche, interactions with humans, etc.), helping them to which helps to build a broad and interesting perspective about life on Earth (Santos *et al.*, 2009).

Insects represent the largest group of terrestrial animals, with more than one million known species (Alves, 1998; Borror & Delong, 2011; Gullan & Cranston, 2017). They play important ecological roles as herbivores, decomposers, predators, and parasitoids (Gullan & Cranston, 2017). In addition, they occupy an important place in the socio-economic life of most human societies, causing losses in crop production and disease transmission, among other things (Costa-Neto, 1998; Pemberton, 1999; Costa-Neto & Carvalho, 2000). However, despite their widespread distribution, abundance, and ecological functions, the topic of insects is rarely covered in elementary and high school. In addition, most teachers do not cover the subject adequately, whether due to lack of biological materials for practical lessons, lack of laboratory structure, or even lack of interest and/or knowledge (Matos *et al.*, 2009). Thus, most students do not have a good knowledge about insects and don't know how to distinguish them from other invertebrates. Therefore, considering the aspects mentioned, the aim of this study was to investigate whether the use of alternative teaching methods would improve the knowledge level of 5th-grade students on the topic "The importance of insects in the environment".

2. Methodology

2.1 Characterization of place and subjects of the study

A social survey was carried out with elementary school students, using a questionnaire, in a combined qualitative-quantitative study (Pereira *et al*., 2018), using simple descriptive statistics with percentage values of absolute and relative frequencies (Shitsuka *et al*., 2014; Akamine & Yamamoto, 2009) and statistical analysis (Vieira, 2021).

The study was conducted with two 5th elementary grades in a public school located in the urban area of the municipality of Teixeira de Freitas, state of Bahia, Brazil, between May and November 2016. The students participating in the study (96 in total) were between 10 and 16 years old, with a predominance of 10-year-olds. This grade level was selected for this study because the students had already learned content on topics such as biodiversity, classification of organisms, invertebrates and vertebrates, ecological niches, habitat, etc., which were related to the topic (insects) worked with the classes.

First, a meeting was held with the teachers and educational staff of the school (principal, counselors, and advisors) to present the proposal, the theme, and topics within the theme to be addressed and worked on with the students. It was also shown the methodology to be used, schedules' the adjustment, the knowledge of the content already worked on by the teachers and, finally, the evaluation of the proposal's implementation by the teachers and technicians of the school.

2.2 Developed activities

To analyze the students' knowledge before and after the practical/educational activities, a structured questionnaire with objective and open-ended questions on "The importance of insects in the environment" was used. This questionnaire was

adapted from the model proposed by Sousa *et al.* (2013). The applied questionnaire aimed to identify the students' conceptions, recognition, curiosity, misconceptions, as well as attitudes, behavior, and interest regarding the proposed topic.

The guiding questions of the questionnaire were: i) Are you interested in the topic: "The importance of insects in the environment"? ii) What is an insect for you? iii) Looking at the following animal pictures, identify the insects (the pictures used for this question were chosen to be well illustrated and not colored to avoid errors based on their quality, shape, and colors); iv) What is the importance of insects to you? (In this question, students were offered eight options that addressed both, positive and negative aspects of insects); v) What do you do when you see an insect? The response options addressed possible attitudes students might take when they see an insect; vi) What are examples of insects you like and why do you like them? and vii) What are examples of insects you do not like and why don't you like them?

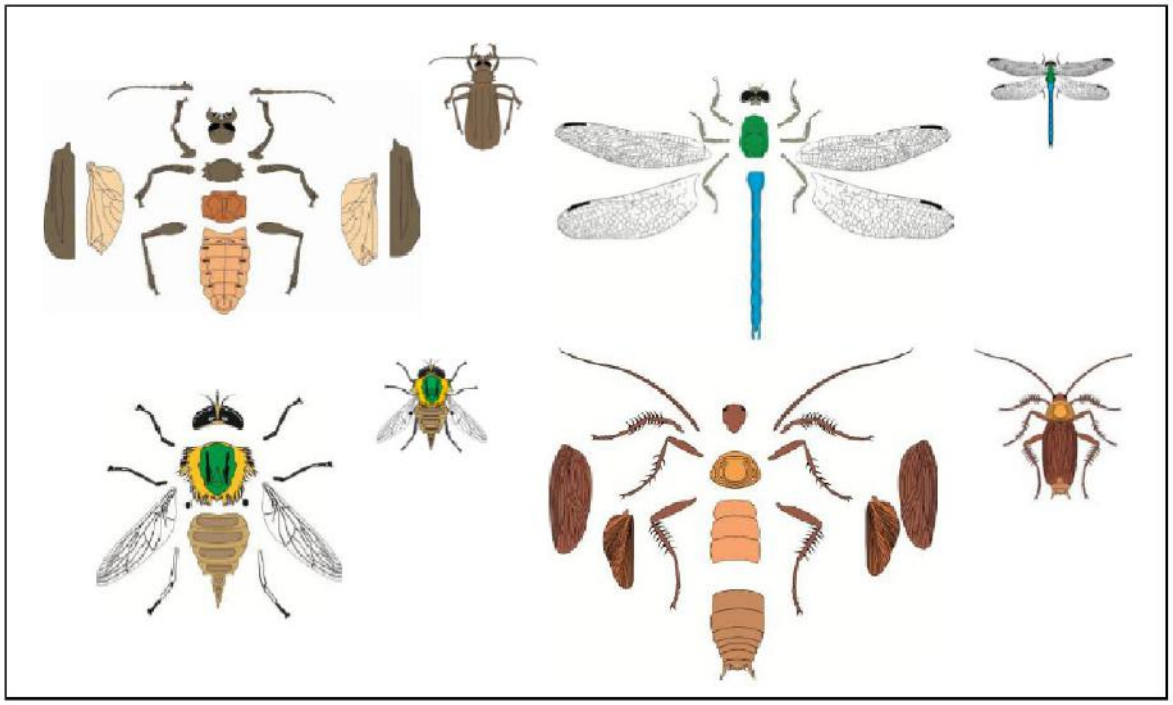
After the application of the initial questionnaire (i.e., before the education interventions), activities were developed with the students in both school and extracurricular contexts. In this sense, the theme of the study was approached through digital resources, films, entomological collections, games, group dynamic activities, and fieldwork. These activities addressed the concepts and main orders of insects, their morphology, biology, the ecological role of these organisms in the environment, and their relationship with humans and other animals.

In the classroom, the activities were developed with the students by some high school students of the specialized course of agriculture and livestock who had already studied the subject of entomology. These students were supervised by a teacher, who is an agricultural engineer with expertise in entomology. Both the students and the teacher were involved in the development of an extension project entitled "The importance of insects in the environment: a case study in schools in Teixeira de Freitas, Bahia State, Brazil", which led to the present study. Some of the classroom activities included lectures on the characteristics, behavior, and biology of insects, their functions in ecosystems such as pollination, biological control, nutrient cycling, pests, and disease vectors, as well as their use as food for humans and animals, in production of medicines and in forensic investigations. In addition to the lectures, the students were shown two movies, "Bee Movie" and "A Bug's Life". They then discussed which aspects of the films reflected the reality of insects and which did not.

As a supplement of the classroom activities, a game called "Insect Life" was played with the students. This activity was based on a game used by Nascimento (2013) and consisted of a "puzzle" and board-like activities (Figures 1 and 2). Before the game began, students were divided into groups of five. To each group it was given insect pictures whose bodies were divided into several parts. Then, the group had the task of reassembling the disassembled figures to match the original. Once the insects were correctly assembled, the tray phase began. In this phase, teams had to choose a representative to roll the dice to see how many squares spots he would walk. When he stopped on a particular square, he and his team had to answer the question corresponding to that square. The questions were formulated based on the information covered in classes. The team that first reaches the end of the field is the winner.

Between lectures and games, students were presented with entomological collections of the orders Lepidoptera (butterflies and moths), Coleoptera (beetles), Diptera (flies and mosquitoes), Hemiptera (bugs, cicadas, leafhoppers, and aphids), Hymenoptera (bees, wasps, and ants) and others such as the order of cockroaches and termites. This activity had to purpose to identify and describe the major insect orders and address the importance of each order in ecosystems.

Figure 1 - Puzzle used in the "Insect Life" game (adapted from Nascimento, 2013).



Source: Authors.

Figure 2 - Giant board used by students in the second phase of the game "Insect Life" (adapted from NASCIMENTO, 2013). In the game, the spot with the question mark indicates the moment when a question from the block of cards must be answered.

Source: Authors.

In addition to the classroom activities, an investigative field activity was also proposed and conducted with the students. In this activity, students were taken to the Instituto Federal Baiano, *Campus* Teixeira de Freitas, where they visited places with different types of vegetation such as vegetable gardens, orchards, pastures, forests, and others. During the visit,

observations, explanations, and collection of insect specimens were made. For the collection, students were divided into groups of five each and used procedures and equipment such as an entomological net, sticky traps for flying insects, and tweezers to collect insects from flowers, fruits, leaves, stored grain, animal droppings, and decomposing organic material. Pitfall traps were used to collect soil insects.

At the time of the collection, students were instructed to note and characterize the locations where each insect was collected, the name of the collector, the method used for collection, and the date of collection. After this collection, the insects were taken to the lab where they were labeled and placed in 70% alcohol or paper bags so that students could see the details, identify them, and then use them in class. In the lab, some insects were placed in stereoscopic microscopes with 40x magnification to see the features that are difficult to see with the naked eye. The insects were identified by order level and by common names in the region.

After all classroom and field activities, a questionnaire was used that contained the same questions as the questionnaire used before the educational interventions. The use of a single questionnaire (before and after the intervention) allowed the evaluation of the effectiveness and the knowledge gain that the students obtained from the pedagogical practices applied.

2.3 Statistical analysis

The data from the questionnaire before and after the application of the activities was put inserted in electronic spreadsheets and analyzed using descriptive statistics of the frequency of the number of answers in each question and presented in graphs. The data collected in both questionnaires was compared by a proportion test (binomial test) at a 5% significance level using BioEstat version 5.0 statistical program (Ayres *et al.*, 2007).

3. Results and Discussion

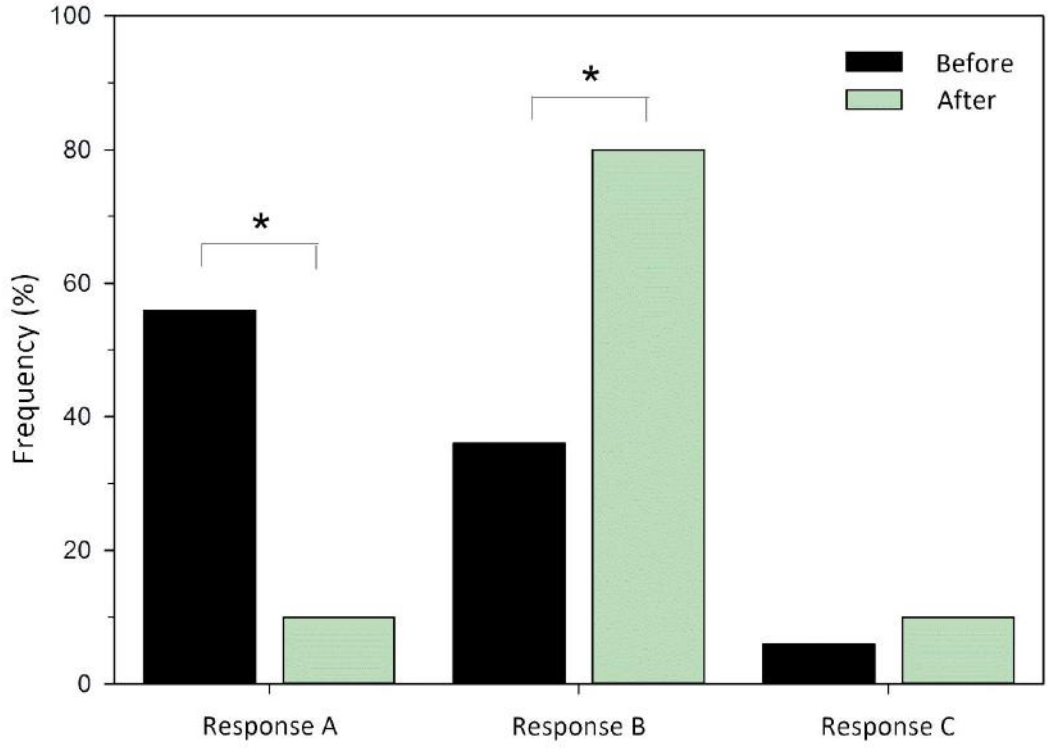
3.1 Concept and recognition of an "insect" by the students

The first question was related to the students' interest in the topic "The importance of insects in the environment". After the interventions, the students' interest increased slightly from 84% to 90%, indicating that they were interested in learning more about the topic regardless of the intervention. Students' interest in insects, as shown in the questionnaire applied before the interventions, could be related to the curiosity that this group of animals arouses in the public, either because of their visual attractiveness and delicacy (e.g., butterflies) or even because of their size and variety of colors (e.g., beetles) (Câmara *et al.*, 2014; Araújo *et al.*, 2019). Another explanation for the students' interest could be the expectation aroused by the proposal to carry out activities that go beyond the usual method of teaching, and that allow them to have direct contact with the subject matter, making them active subjects in the learning process (Silva & Peixoto, 2003; Matos *et al.*, 2009).

In response to the question "What is an insect to you?" only 36% of the students ticked the correct answer in the initial questionnaire (i.e., before the intervention) (Figure 3). However, after the intervention (lectures, games, etc.), 80% of the students ticked the option (answer B) that best defines an insect morphologically, indicating a positive outcome of the interventions implemented (Figure 3). Comparing the data before and after the activities, it was noted a significant difference ($P < 0.001$) in the percentage of correct answers given by the students. In this specific case, the definition of what an insect is tended to focus on the general morphological features that define this class of animals (body division, wings, and legs) and habitat, as these are the features described in most entomology textbooks (Borror & Delong, 2011; Gullan & Cranston, 2017). However, these morphological features do not seem to be the most perceived and used to define an insect, hence the results in the pre-test. In a study conducted by D'escoffier (2021) with 4th-grade students from two schools in state of Rio de Janeiro, less than half of the students surveyed were able to correctly identify an insect (i.e., based on characteristics such as the

number of legs and wings) and chose options that reflected their perception of these animals (disgusting and small). These results draw our attention to the care with which certain content must be treated in the classroom to correctly teach scientific knowledge to students.

Figure 3 - Students' knowledge about insects before and after the intervention. Option A: Insects are small animals that have many legs and live underground; Option B: Insects are animals that have 6 legs, whose bodies are divided into 3 parts, they have antennae, can have wings, and live in different environments; Option C: Insects are animals that have 8 legs, have wings, have bodies divided into 2 parts, and live only on the ground. * Indicates a significant difference ($P < 0.001$) between groups based on the binomial test.



Source: Authors.

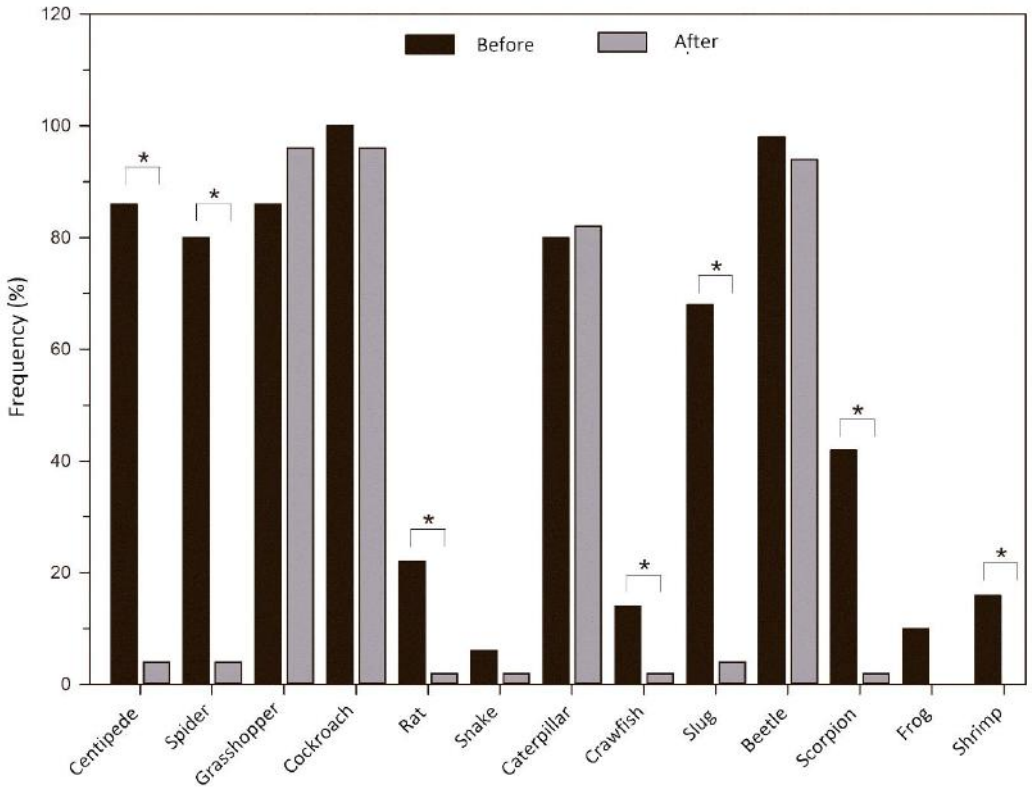
The third question was about recognizing and distinguishing insects from other arthropods and/or small animals based on pictures. More than 80% of the students ticked the pictures related to insects, such as the grasshopper, the cockroach, the caterpillar, and the beetle, in both questionnaires applied before and after interventions (Figure 4). However, in the questionnaire applied before the interventions, most of the students (in some cases more than 80%) also ticked other animals not belonging to the class Insecta, such as the centipede, the spider, the frog, the mouse, the snake, and others (Figure 4). This indicates that although students correctly labeled the pictures of insects, they could not distinguish them from other organisms. In various social and cultural contexts, the term insect is used as a broad taxonomic category that includes insects as well as other arthropods and animals that do not belong to the class Insecta (Costa-Neto & Carvalho, 2000, Silva & Costa-Neto, 2004). In consistency with our results, several other studies also found that participants could not distinguish insects from other invertebrates (Costa-Neto, 2006; Cereto & Lopes, 2008; Ulysséa *et al.*, 2010).

Among arthropods other than insects, spiders, centipedes, and scorpions were most frequently mentioned by students. These organisms were also most frequently mentioned in other studies among animals that do not systematically belong to the

class Insecta (Costa-Neto & Pacheco, 2004; Costa-Neto, 2006; Ulysséa *et al.*, 2010). Several other previous studies have also shown that other organisms that do not belong to the class Insecta are referred to as insects, not only by children, but also by subjects of education for youths and adult (EJA) students, adults, and even teachers in urban and rural areas (Bartoszeck & Bartoszeck, 2012; Montenegro *et al.*, 2015; Amaral & Medeiros, 2015; Silva & Costa Neto, 2004). In particular, a reference is made to a study conducted to analyze the perception of the ethnocategory "insect" by students from different disciplines (health, biology, engineering, education, etc.) of a private higher education institution in the state of Minas Gerais, in which several other organisms (spider, tick, centipede, earthworm, etc.) were cited by students as examples of insects (Siqueira *et al.*, 2018).

After the intervention, the percentage of correct answers by students was more than 95%, which was significantly different ($P < 0.01$) from the percentage of correct answers in the questionnaire before the intervention (Figure 4). This result indicate that the intervention activities adopted improved students' perception about insect features. In a similar study with 7th grade students in a public school in the state of Pará that aimed to assess students' knowledge of the distinction between insects and other arthropods, it was also observed a 53% increase in the percentage of correct student answers responses after interventions with specific applied teaching methods (Cajaiba & Silva, 2015).

Figure 4 - Identification of animals within the "insect" category before and after the intervention. * Indicates significant difference ($P < 0.01$) between groups based on the binomial test.



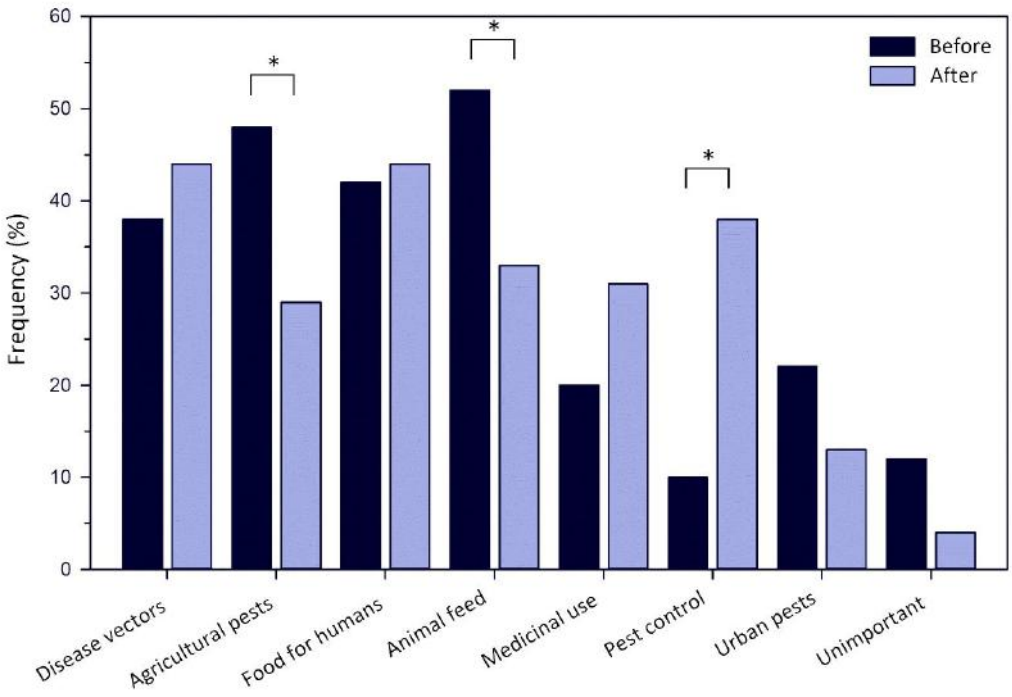
Source: Authors.

When asked about the importance of insects, students mentioned both positive and negative aspects. For negative aspects, most students saw insects as disease vectors and agricultural pests (Figure 5). This understanding could be due to students' proximity or coexistence with insects. Many of the students may have more contact with household insects that are traditionally associated with disease. Indeed, outbreaks of dengue infection and other associated diseases occur frequently in

the municipality where the study was performed. On the other hand, the view that insects are pests could be related to the fact that many agricultural activities are carried out in the municipality. In addition, this negative connotation of students could be due to the influence of the media, which emphasizes the negative effects of insects, usually stressing that they are organisms that transmit diseases and must be eradicated (Costa-Neto & Carvalho, 2000). D'escoffier (2021) confirmed the results of this study, finding that most 4th grade students from two urban schools in the state of Rio de Janeiro also perceived insects as disease vectors, although this perception was stronger among students from the school located in an area with worse socioeconomic conditions.

The most frequently mentioned positive aspect by students was that insects are important for feeding other animals (Figure 5). However, in the questionnaire used after the intervention, the percentage of students who also mentioned other positive aspects of insects, such as the use of these organisms for pest control and medicinal purposes, increased significantly (Figure 5). This increase in students' positive perceptions of insects was likely due to the influence of the intervention since topics such as biological control and entomotherapy were discussed with students.

Figure 5 - Percentage of student answers responses regarding perceptions of the importance of insects before and after the intervention. * Indicates significant difference ($P < 0.05$) between groups based on the binomial test.



Source: Authors.

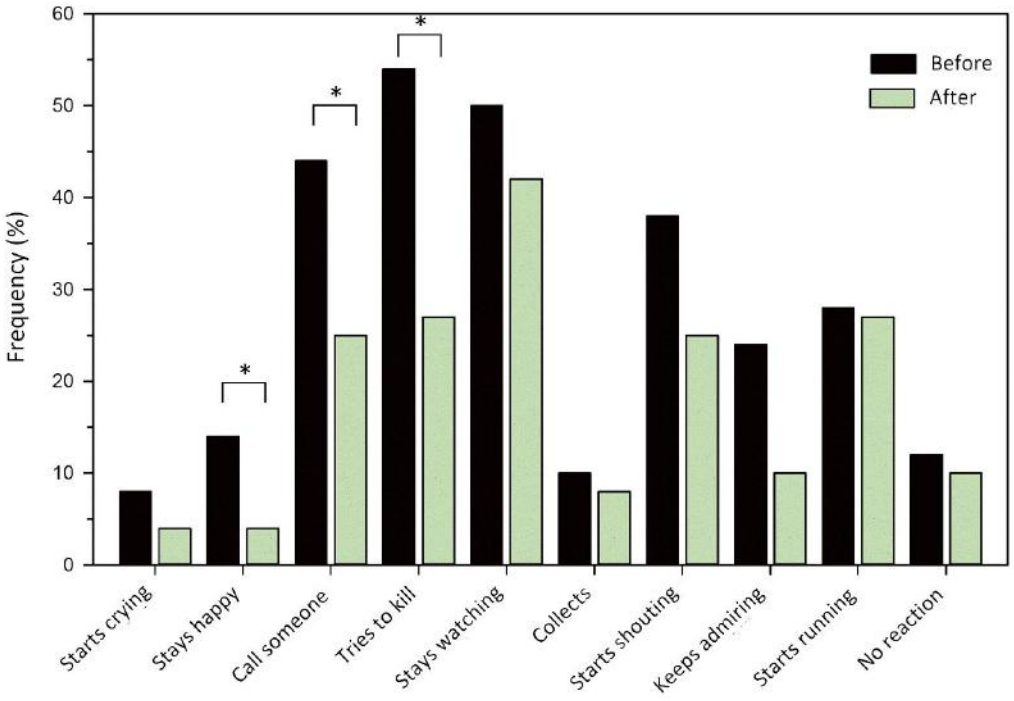
3.2 Students' attitudes, behaviors, and feelings toward insects

To learn more about students' attitudes/behaviors toward insects, a question was included in the questionnaire that focused on the reactions of the students' when seeing an insect. The most frequently checked answers in the pre-intervention questionnaire were to kill and observe the insect, to scream, and to call someone for help (Figure 6). This result shows the students' fear of insects and their primary attitude toward this fear. Such behaviors and attitudes are understandable because some insects are associated with negative factors that affect human interests, such as disease transmission or agricultural pests. Another aspect to be considered is how a certain knowledge is constructed, often through distorted or biased anthropocentric

perceptions. In the specific case of insects, caricatured and shocking images are often used to represent them, evoking fear and horror and they are usually judged as being disgusting, dangerous, repulsive, and useless organisms for society (Silva & Delmônico, 2011; Trindade *et al.*, 2012).

Interestingly, in the questionnaire used after the interventions, the frequency of students reporting attitudes that showed fear or dislike of insects decreased (Figure 6). This could be a result of the actions taken during the intervention, where students had more contact with insects through field collections, laboratory manipulations, and entomological collections. Another interesting aspect is that during the development of the educational activities, the students realized that there was no problem or danger in touching the insects if the proper techniques were used. They also realized that some insects, even if they seem dangerous, are harmless and can be useful for the environment, such as earwigs, ladybugs, bees, some beetles, and bugs.

Figure 6 - Frequency of students' attitudes/reactions when encountering an insect, pre- and post-intervention. * Indicates significant difference ($P < 0.05$) between groups based on the binomial test.



Source: Authors.

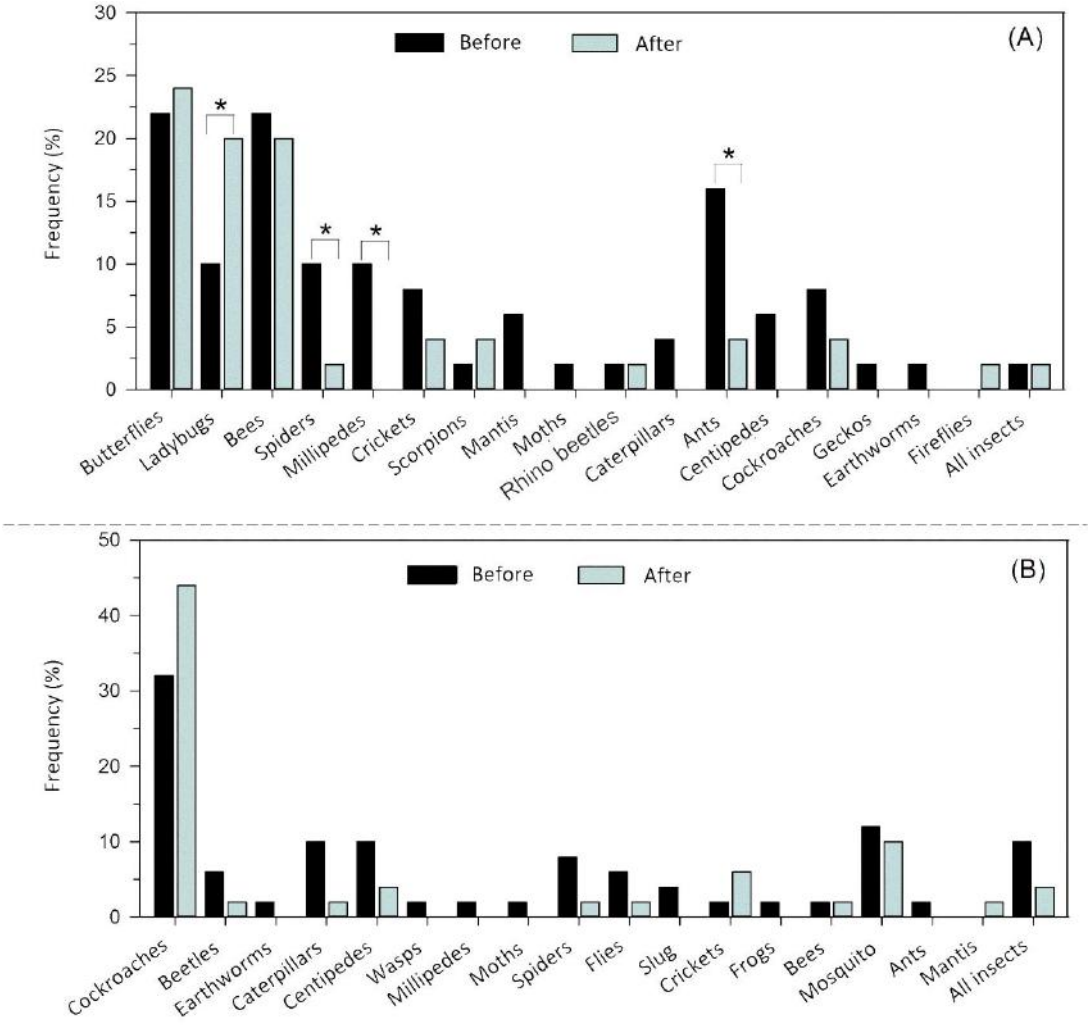
Finally, the last two questions of the questionnaire aimed to find out the students' feelings about insects. In this step, students were asked to name the insects they liked or disliked, as well as the reasons why they liked or disliked the named insects. Students most frequently named butterflies, ladybugs, and bee as the insects they liked the most (Figure 7A). The reasons students most often gave for liking these insects were that they were pretty or produced honey (Figure 8A). The insect that students most often mentioned as the one they liked the least was the cockroach. The reason for this was that they thought the cockroach was a disgusting insect.

The results of the last two questions showed that there is some connection between the organisms mentioned and the reasons for naming them. For example, the insects that were named most often by the students can usually evoke a positive feeling in them, usually because of their standards of beauty and friendliness, as is the case with butterflies, or even because of the possibility of using by-products for food and medicine, as is the case with bees. On the other hand, negative feelings, such as those directed to cockroaches, may be associated with the fact that they evoke feelings of fear or disgust in most people

(Costa-Neto, 2005). According to Silva & Costa Neto (2004) and D'escoffier (2021), when it comes to arthropods, insects are associated with diseases that are harmful to humans and appear disgusting, harmful, or dangerous, and when positive aspects are mentioned, they no longer belong to the class Insecta in the imagination of society but receive a different classification. Therefore, contempt, fear, and dislike are the feelings most often associated with the Insecta class.

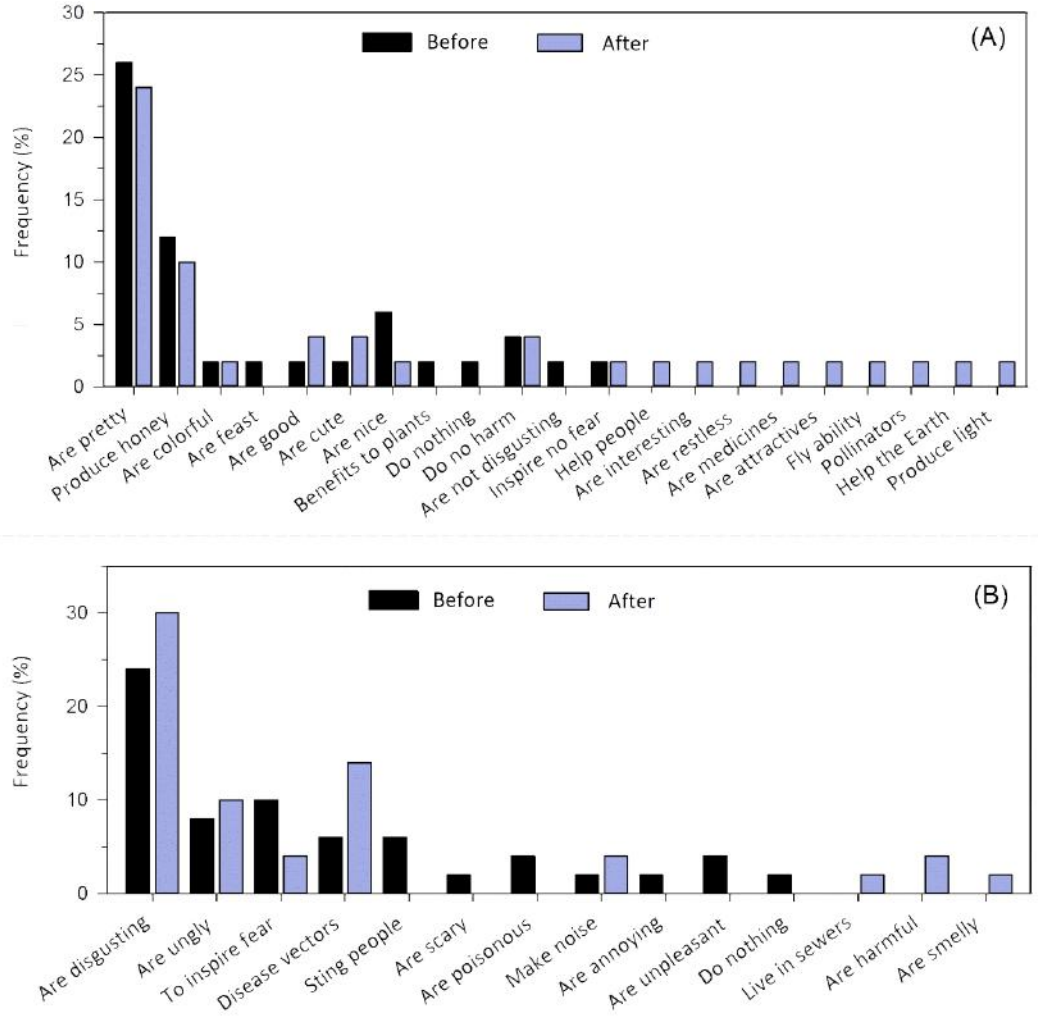
It is interesting to point that, in some cases, the frequency of the students' answers regarding their feelings about insects changed when comparing the data from the questionnaires before and after the intervention, demonstrating the effectiveness of these intervention measures. For example, students liked ladybugs more and ants less after the intervention (Figure 7A). Changes in students' perceptions of insects after educational interventions have also been found in other studies (Cajaiba & Silva, 2015; Brito & Souza, 2020).

Figure 7 - Insects named by students as those they like (A) and those they dislike (B), before and after the intervention. * Indicates significant difference ($P < 0.05$) between groups based on the binomial test.



Source: authors

Figure 8 - Reasons given by students for liking (A) and disliking (B) insects, before and after the intervention. * Indicates significant difference ($P < 0.05$) between groups based on binomial test.



Source: Authors.

4. Final Considerations

The use of alternative teaching methods should be encouraged in institutions since the earliest grades, to link the content covered in the curriculum components with the development of practical activities. In this way, it is possible to promote intensive student participation in the learning process. For quality teaching of a particular curriculum component, it is not enough to select a textbook or a workbook. The teacher must be careful to use instructional strategies and resources that allow students to learn in a more meaningful way.

Students' knowledge, perceptions, attitudes, and behaviors regarding insects changed and expanded significantly when comparing data before and after the teaching methods used. Thus, it appears that pedagogical experiences that allow students to have more contact with the object of study and make them active subjects in the teaching-learning process can facilitate the construction of their knowledge.

In addition it is worth to highlight that teaching requires research (FREIRE, 1996) and that the use of teaching tools to build know ledge requires knowing methodologies capable of trigger students curiosity and creativity. Another aspect to be considered is the progressive improvement and training of the educator, not only for the use of new teaching methodologies but also for the use of technological tools that add to the teaching and learming process.

In this context, future work requires research involving high school students in medium education as well as students in fundamental education. These investigations should contemplate the use of different methodologies aligned with playful strategies that promote learning, taking into account the student's perceptions, points of view and previous repertoire of knowledge on the topic to be addressed.

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Declaration of interest statement

All authors declare that they have no conflicts of interest

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