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ARTICLE

Teaching Biology by investigation: a case study in the context of education for young adults and adults*

Monique Cesnik Martins dos Santos[I]
Jefferson de Barros Batista[II]
Maria de Fátima Camarotti[III]
Anabelle Camarotti de Lima Batista[IV]

ABSTRACT
Teaching by investigation is characterized as a practice that aims to encourage students' protagonism, critical thinking and autonomy. The methodological approach was quantitative-qualitative, descriptive, and made use of participant observation. The data, collected through questionnaires, led to a qualitative analysis of the students, who demonstrated motivation, leadership and autonomy in the construction of knowledge. This resulted in an affirmation measured quantitatively by the significant increase in the number of students who stated, in the questionnaire, that they "understand without difficulty" the topics covered. These results pointed to a positive evaluation of the theme and methodological approach used. At the end, the students revealed, in their perceptions and attitudes, the development of meaningful learning and the potential to multiply the knowledge built, acting as transformers of their own reality.

KEYWORDS
active methodologies; protagonism; meaningful learning.

[I]Secretaria de Educação do Estado da Paraíba, João Pessoa, PB, Brazil.
[II]Instituto Federal de Educação, Ciência e Tecnologia da Paraíba, Cabedelo, PB, Brazil.
[III]Universidade Federal da Paraíba, João Pessoa, PB, Brazil.
[IV]Universidade Federal da Paraíba, Bananeiras, PB, Brazil.
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O ENSINO DE BIOLOGIA POR INVESTIGAÇÃO:UM ESTUDO DE CASO CONTEXTUALIZADO NO ENSINO DE JOVENS E ADULTOS[1]

RESUMO

O ensino por investigação caracteriza-se como uma prática que visa estimular o protagonismo, o pensamento crítico e a autonomia do aluno. A abordagem metodológica foi quantitativo-qualitativa, descritiva e fez uso de observação participante. Os dados, coletados por meio de questionários, resultaram na análise qualitativa dos alunos, que demonstraram motivação, liderança e autonomia na construção do conhecimento. Isso resultou em uma afirmação medida quantitativamente pelo aumento significativo no número de alunos que declararam, no questionário, que "entendem sem dificuldade" os temas abordados. Esses resultados apontaram para a avaliação positiva do tema e da abordagem metodológica utilizada. Ao fim, revelaram, por meio de suas percepções e atitudes, o desenvolvimento de aprendizagens significativas e o potencial de multiplicar os conhecimentos construídos, atuando como transformadores de sua realidade.

PALAVRAS-CHAVE

metodologias ativas; protagonismo; aprendizagem significativa.

ENSEÑANZA DE BIOLOGÍA A TRAVÉS DE LA INVESTIGACIÓN: UN ESTUDIO DE CASO CONTEXTUALIZADO EN LA ENSEÑANZA DE JÓVENES Y ADULTOS

RESUMEN

La enseñanza por investigación se caracteriza por ser una práctica que tiene como objetivo fomentar el protagonismo, el pensamiento crítico y la autonomía del alumno. El enfoque metodológico fue cuantitativo-cualitativo, descriptivo y mediante observación participante. Los datos recolectados a través de cuestionarios dieron como resultado el análisis cualitativo de estudiantes que demostraron motivación, liderazgo y autonomía en la construcción del conocimiento. Dando como resultado un enunciado medido cuantitativamente por el aumento significativo del número de alumnos que manifestaron, en el cuestionario, que "comprenden sin dificultad" los temas tratados. Estos resultados apuntan a la valoración positiva del tema y el enfoque metodológico utilizado. Al final, revelaron, a través de sus percepciones y actitudes, el desarrollo de aprendizajes significativos y el potencial de multiplicar los conocimientos construidos, actuando como transformadores de su realidad.

PALABRAS CLAVE

metodologías activas; protagonismo; aprendizaje significativo.

INTRODUCTION

This study focuses on investigative teaching as a methodological proposal for classes in Youth and Adult Education (*Educação de Jovens e Adultos* — EJA). The need for this proposal arises from reports by students and teachers who feel the lack of contextualization of themes in everyday life.

According to the National Education Guidelines and Framework Law of 1996 (*Lei de Diretrizes e Bases da Educação Nacional* — LDBEN), there must be a connection between the topics covered at school and the students' daily life, so they will be able to apply the acquired knowledge to concrete situations (Brasil, 1998; 2000; Ilha *et al*., 2014). However, Assis and Araújo Jorge (2018) noticed that the books distributed in Brazil do not favor an education that promotes criticality, autonomy, and citizenship, as outlined in the LDBEN and the National Curricular Parameters (*Parâmetros Curriculares Nacionais* — PCN) (Brasil, 1996; 2006).

In this sense, we suggest the contextualization of teaching in EJA through research processes carried out by the student and guided by the teacher. The National High School Curriculum Guidelines (*Diretrizes Curriculares Nacionais do Ensino Médio* — DCNEM) support this idea in article 12, when recommending "to adopt teaching and learning assessment methodologies that encourage student initiative;" and in article 13, when suggesting that curricular propositions must have "research as a pedagogical principle, enabling the student to be a protagonist in the investigation and the search for answers in an autonomous process of (re) construction of knowledge" (Brasil, 2012a).

For this contextualized approach, we propose the problematization of everyday issues, aiming to find motivational references to lead students to seek answers to their questions. As stated in the PCN: "Meaningful learning presupposes the existence of a framework that allows students to identify and identify with the questions proposed" (Brasil, 2000).

In inquiry-based teaching, students' prior knowledge is used, and hypotheses, research, arguments, and explanations are formulated. Throughout this process, students become involved with certain aspects of scientific work. In this way, this type of teaching constitutes a means and an end for the teaching-learning process. As a means, because it is the path that leads to the understanding of scientific content; and as an end because it results in the development of skills and abilities related to the scientific method (Carvalho, 2013; Sasseron, 2013; Castelar, 2016; Camargo and Daros, 2018).

In this sense, we believe that the teaching of Biology by investigation in the context of cardiovascular diseases has the potential to bring the discipline closer to the students' daily life and stimulate protagonism and autonomy for the construction of knowledge. In this context, we hypothesize that the study of "cardiovascular diseases" will be better carried out through an investigative, contextualized, interdisciplinary approach integrated with the didactic unit "human physiology" for the teaching of Biology in EJA. Thus, we intend to stimulate protagonism, critical thinking, and autonomy, enabling students to learn continuously.

METHODOLOGICAL APPROACH

STUDY DESIGN

Given the nature of the research, we used a quantitative, qualitative, and descriptive approach. The qualitative methodological approach defends that humans are different from objects and, therefore, not passive; rather, they interpret and interact with people and the environment. The essential characteristics of this type of approach include the researcher's direct contact with the situation studied, the obtention of predominantly descriptive data, a concern to portray the participants' perspective, and a greater emphasis on the process rather than on the product (André, 2009; Ludke and André, 2013; Guerra, 2014).

Descriptive data were collected through participant and naturalistic observation and questionnaires. In this type of examination, the researcher plays the objective role of observer, keeping in view of the phenomenon under investigation; however, he is not detached from the context and also plays the subjective role of participant, influencing and being influenced by the process. The naturalistic character of such observation is due to it taking place in a real environment, with data being recorded as they occur spontaneously (Eiterer and Medeiros, 2010; Lakatos and Marconi, 2010; Ludke and André, 2013).

The questionnaire was adapted from Bahar, Johnstone, and Hansell (1999). It was applied in two moments, pre and post-test, and dealt with a subjective analysis with quantification of terms. The first application was before the methodological intervention, and the second two weeks after the "culmination moment" of the methodology (Health Fair).

In the pre-test, only one question was asked, and it aimed to verify the self-evaluative perception of each participating student regarding topics related to cardiovascular diseases. We selected these topics because they arouse questions, doubts, and interest from the EJA public, as registered in a previous diagnosis conducted on the first day of classes in 2018; as well as because they are not addressed in-depth in the teaching materials available for the EJA modality. The terms quantified for each topic were: I don't know (I've never heard of it, I don't know what it is about); I've heard of it, but I don't understand this topic; I superficially understand this topic, I have many doubts; I understand this topic well, I have little difficulty; I understand without difficulty.

In the post-test, the same question was asked to verify if there was an improvement in self-perception after the investigative methodology was applied. In addition, the students were asked about the methodology applied. The following are examples of questions from the post-test: How do you evaluate the subjects and contents covered in the project? How do you rate your experience in developing and presenting your work in Health? How do you evaluate the interaction between school subjects and your daily life? How do you evaluate the contribution of other disciplines to the understanding of topics?

STUDY AREA AND TARGET AUDIENCE

The activities were conducted at the Dom José Maria Pires State School of Elementary and Secondary Education, located in Bairro das Indústrias, in João Pessoa, state of Paraíba.

In 2019, approximately 180 enrollments were registered in the EJA modality, distributed into three cycle-V classes and five cycle-VI classes. The study took place during the second semester of the 2019 academic year. The public chosen for the pedagogical proposal comprised students from the cycle-VI classes (equivalent to the third grade of regular high school) of the EJA modality night school.

These classes were chosen so as to continue the pedagogical work started in 2018 by the first author of this paper, when she started working at the school. Contact with such classes over a school year brought her knowledge of the students' profile, their characteristics, difficulties, and interests. Such elements were fundamental for the planning of the activities proposed in this study. The choice of its central theme, "Cardiovascular Diseases," as the starting point for the investigative process is a consequence of her previous experience with the students and of the fact that such a topic is aligned with the curricular topics set out for cycle VI of the EJA.

Because the present proposal is interdisciplinary and involves the participation of the entire school community, it was put on the agenda of the pedagogical meetings of the 2019 school year and integrated the Annual Plan of the discipline. Thus, the date of the Health Fair (the culmination of the investigative process) was jointly defined and included in the school calendar.

ETHICAL ASPECTS

This study took into account the ethical aspects of research involving human beings, as defined by Resolution no. 466/12 of the National Health Council (Brasil, 2012b). Before its application, the study was approved by the Research Ethics Committee of the Health Sciences Center of the Universidade Federal da Paraíba in August 2019, under opinion number 3,521,632. Although all students participated, only 70 presented the Free and Informed Consent Term (ICF) signed. The others dropped out of school activities in the period or did not present the term, among them those under 18 years old. For this reason, all calculations under analysis are for a total of 70 participants.

DATA ANALYSIS

The initial data of the pre-test served as a diagnosis to support adjustments in the pedagogical proposal and as a parameter for comparison with the data from the post-test. Every student answer and perception along the application of the entire project was cataloged (Bardin, 2016). The students were divided into classes A, B, C, D, and E and numbered according to the school's alphabetical attendance list. Thus, student A12 represents a member of class A who is in position 12 of its attendance list.

To compare the results from the pre and post-tests regarding the students' degree of knowledge, Student's t-test was employed to point out significant differences. The answers for questions 1 and 2 were grouped for all classes and terms in the pre- and post-test. We used Excel tools (Office 365 Personal 2018 Package) and Graphpad to analyze the data.

DIDACTIC SEQUENCE

A didactic sequence was proposed to implement teaching by investigation, which was applied following the order of steps as synthetically described in Chart 1. The sequence consists of ten steps and includes the proposition of hypotheses, discussions, research, interdisciplinarity, culmination, and critical assessment.

RESULTS AND DISCUSSION

The results were analyzed during the application of the didactic sequence. Some aspects favored the students' involvement with the investigative methodological approach and the teaching-learning process. Thanks to the interdisciplinary aspects of the topic, the students' autonomy was observed when they asked for help from other teachers to improve their work. Since the students showed interest in the topic of "Cardiovascular Diseases," the other Biology topics were developed normally during the semester.

In the students' answers, we verified that the contextualization of the project in the health area and its culmination in a Health Fair presentation attracted collective interest and favored teamwork, which is essential for a better investigative approach: "*It's great! Who doesn't know someone in the family who has these diseases? We need to take care of ourselves and guide people at home and friends*" (Student A12); "*It is very good to have a fair only for health because it is in everyone's interest. Those science fairs aren't everyone's favorite*" (Student E6); "*It is good, teacher, this exhibition, because EJA never has anything*" (Student C1); "*It's good, an event for the night school, because when there's something at school we can't participate because we're working*" (Student D12).

INVESTIGATIVE APPROACH

In the investigative approach, the line of reasoning rests with the student, unlike what happens in expository teaching, where the line of reasoning is guided by the teacher (Carvalho, 2013).

In the present work, the teacher's mediation aimed at promoting protagonism and encouraging investigation by the students, thus transferring to the student the task of reasoning, carrying out research, searching, and constructing answers and solutions. The teacher's role was to suggest procedures, highlight gaps, and clarify doubts, thus offering adequate conditions so that each group or student could, individually, advance in the construction of collective knowledge.

Chart 1 – Moments of the didactic sequence with the approaches developed in each step. Duration time is based on 30-minute lessons.

Moments	Duration	Approaches
1 Raising hypotheses	2 lessons	• Survey of previous knowledge on the subject. • Problematization. • Formulation of hypotheses.
2 Socialization of hypotheses	2 lessons	• After extra-class investigation — exposition of investigated hypotheses, information and materials obtained from research and considerations. • Encouragement of argumentation.
3 Theme and content integration	2 lessons	• Continuation of exposition of group research results. • Encouragement of integration of investigated topics with the physiology contents taught.
4 Interdisciplinarity Portuguese × Biology - Interview script - Interview*	4 lessons 3 lessons	• Exercising textual production, learning to build and structure a text according to the chosen textual genre — interview. • Using biological knowledge as content in text production. • Scheduling and conducting an interview with a Health professional — a nutritionist.
5 News – Theme and content integration	2 lessons	• Exercising reading and interpretation, based on another textual genre — the news — still in association with the Portuguese subject. • Developing the ability to synthesize and systematize information contained in the text (news) by relating it to previous knowledge, thus constructing new, broader and more elaborate explanations. • Developing oral language and reflecting on health-promoting attitudes.
6 – Interdisciplinarity Sociology and Biology	2 lessons	Understanding the relationship between socioeconomic factors and cardiovascular diseases through interdisciplinarity — allows adding other causes or factors that intervene in the reality investigated, offering more elements to expand knowledge and discussions on the subject.
7 – Integrating languages and disciplines - Biology - Mathematics - Geography	2 lessons 4 lessons 2 lessons	Integrating languages as per data contained in images, charts, tables, maps, infographics and geographic data. • Reading of laboratory and imaging tests. • Analysis of statistical data. • Analysis of the spatial distribution of cardiovascular diseases among the regions of Brazil.
8 – Action plan	4 lessons	• Planning of presentation to the school community. • Analysis of the different aspects to be considered in the presentation. • Encouraging autonomy and decision-making from the students.
9 – Health Fair	5 lessons	Time to welcome the school community, offering presentations/interventions.
10 – Critical assessment	2 lessons	Raising the students' impressions about the pedagogical path taken.

*It is suggested that the interviews take place in a large place and that the invitation is extended to the school community. The interviews will serve to answer investigations regarding the study of the subject in question, "Cardiovascular diseases," and its relationship with the nutrition of the body. If the groups feel the need, other professionals can be invited.

The dialogue reproduced below demonstrates the teacher's procedure when facing questions in one of the classes. However, similar dialogues between the students occurred in all five classes of cycle VI of the EJA:

> Student E10*: But then, teacher, explain now, is it like that or not?*
>
> Teacher: *That's what I too want to know, you guys are going to answer.*
>
> Student E10: *But how, if nobody here knows?*
>
> Student E2: *But hasn't she already said? We have these hypotheses, and then we do research to explain whether everything we talked about there is true or not.*
>
> Student E10: *I don't believe that, teacher! Are you going to let us go like this? You filled our heads with doubt. Now I want to know, can't take it, I'll have to get home and do some research...*

Even though all the guidelines for research were given, some students, used to a traditional expository approach where information is transmitted, took longer to understand the type of stance that was being encouraged in the proposal. However, upon realizing their active role in the process, they did not offer resistance once they were already involved with the subject and the ongoing dynamics, and surprisingly demonstrated curiosity, interest, and personal motivation to proceed with the activities proposed.

Hypothesis formulation and investigative thinking led students to use reading as a source of knowledge and answers to their questions. This dynamic favored a greater involvement with the texts recommended and gave more meaning to reading when compared to the traditional teaching approach. For Marcondes, Menezes, and Toshimitsu (2010), reading means to be psychologically willing to ask questions, to seek answers, and to know where to find them.

The reading dynamics encouraged the habit without the imposition of texts, to awaken, in the students, the pleasure of reading and asking questions about the text, establishing a dialogue with what is read. Developing reading skills contributes to the students' autonomy, enabling them to apply reading for permanent learning, even outside school.

THE IMPORTANCE OF INTERDISCIPLINARITY

The coordination of different languages and interdisciplinarity were very relevant in the investigative approach, as they expanded the conditions for students to develop their own learning. They facilitated the understanding of how broad a theme can be when analyzed from different angles and tools. The PCN state that interdisciplinarity does not dilute the disciplines, rather it integrates them from the understanding of the multiple causes or factors that intervene in reality, and works with all the languages necessary for the construction of knowledge (Brasil, 2000).

Ferreira, Muenchen and Auler (2019) report the interest of high school teachers in working with themes in an interdisciplinary approach to develop broad, concrete knowledge. However, many teachers still cannot see outside the box. In this study, throughout the learning process, interdisciplinarity occurred as something necessary and directly sought by the students, leading the teachers to engage in the project. The students asked the Portuguese teacher for assistance with their writing, asked the Mathematics teacher to help them assemble graphs, asked the Geography teacher to help them organize their maps, and asked the History teacher for help finding the history of diseases. Students participated in lectures on health promoted by the school for additional information. These were open to the community and supplemented the knowledge that was being collectively constructed.

Using the dynamics laid out in in the didactic sequence and interaction between disciplines, it was possible to include and explore different languages and text types, such as graphs, tables, infographics, figures, maps, exam images, laboratory tests, food labels, medication package inserts, newspaper, news, interviews and life experience reports. These were brought up along the process both intentionally, encouraged by the Biology teacher but also featuring in suggestions and proposals from teachers of the other disciplines, as well as spontaneously, through research and the students' initiative.

It was also the students' idea to use plastic and visual art to make didactic models and select didactic videos. Many of these languages were selected and employed as support material for the presentation.

In an investigative approach, when students are required to autonomously build their own explanations, all the languages necessary for the construction and expression of knowledge must be taken into account, not only the verbal type. For Carvalho (2013), the mathematical language, tables, graphs, figures, maps, among others, must be integrated with the verbal language coherently so that the student can become familiar with them and use them for the construction and expression of knowledge.

DEVELOPMENT OF BIOLOGY CONTENT

At each step of the didactic sequence, the students produced more elaborate explanations, incorporating the terms and processes of the biological systems addressed (in parallel to the didactic sequence).

A teacher-student exchange which occurred during moment 5 (News and integration) illustrates how knowledge was being organized with a view to building an explanation. By associating previous knowledge, the topics studied in human physiology, research carried out on the topic, and news reports, a student made a comparison, then drew a rectangle in the notebook, and, while filling it, said:

> Student C9: *It is like an elevator built to operate according to a certain load: if you increase the number of people inside it, it will show some defects and difficulty in working, until it can stop completely. So our body is the same thing: the blood ves-*

sels work according to a certain amount of fluid, cells, and nutrients. If you increase the amount of fat or sugar, you will overload the system and everything related to it. The organs that people have the most problems with are the heart, the brain... The edges, the wall of the blood vessel ends up clogging, and that's why what was supposed to reach the organs cannot make it.

Teacher: *What was supposed to reach the organs*?

Student C9: *Oxygen and nutrients.*

Teacher: *Where do they have to go?*

Student C9: *All over the body!? The organs!? Oh! The cells, teacher! To each of the cells (laughs).*

In another class, after a similar discussion, a student concluded: "*So, if this is the case, any organ can have a heart attack. Not just the heart!*" (Student E2). Therefore, the student built a concept beyond the one being discussed (myocardial infarction), which was more in-depth and required a greater contribution of research for clarification.

Each moment also offered the opportunity to resume and review content from previous steps and to foster new, unforeseen or unplanned knowledge. The interview (moment 4) can be taken as an example, as it involved all the classes and, consequently, all specific themes in an integrated way.

At that point, the dynamics of the interview were based on the script developed by the students and on spontaneous comments. This learning moment focused mainly on a balanced and healthy diet, as it relates to aspects of cardiovascular diseases and their risk factors. It was also possible, however, to move on to other topics according to the questions raised, carrying out a convenient resumption and integration of contents, as listed below:

- Biochemistry — micro and macronutrients: content addressed in classes during the previous year. Associated with knowledge about the digestive, endocrine and nervous system, cardiovascular diseases, and risk factors such as obesity, diabetes, hypertension, and dyslipidemia, it promoted a deeper understanding of such phenomena;
- Genetics: topic addressed in the previous semester. Agricultural genetic manipulation/transgenics was approached, revising concepts and processes related to DNA, genome, and genes. New concepts such as Nutrigenetics and Nutrigenomics were also presented, which had not been previously covered in pedagogical work, but were relevant for content integration;
- Human physiology:
    - digestive system — review of compartments and their functions;
    - food dynamics in hypertense, diabetic and dyslipidemic individuals;
    - diet *versus* atherosclerosis/ heart failure/ cerebrovascular accident;

    - influence of food/diet on the endocrine, nervous, excretory and cardiovascular systems.
- Science and Technology: food technology/ food additives/ industrial production;
- Citizenship: consumer rights/ the importance of reading labels/ food safety;
- Public Policies: school nutrition.

CONTEXTUALIZATION OF THEMES IN PERSONAL EXPERIENCE

Throughout the explanations given and investigations made, students were able to contextualize the topics covered in aspects of their personal and professional experience, as the following statements show:

> Student D12: *I work in a juice factory. The juice is stored inside metal drums and lasts for three years, and then it undergoes reprocessing, after that, the high microbial content decreases. That is the food industry! People don't know what they consume.*

> Student C2: *It's complicated... (to follow a healthy diet) because if you look closely, everything is poisoned, nothing is totally good, there's always something. Those who may be able to have a healthy diet are the people who live in the countryside, they plant and know what they are eating! You go to the supermarket and see that looks can be deceiving. There are things there that seem to be so healthy, but as we can see (in the discussion), they are not. So, we have to cut down on all kinds of food and look for information.*

This learning experience helped the students to comprehend the importance of school knowledge for their understanding of the world and of their life context, and recognize knowledge as an important tool for critical and conscious decision-making. Freire (1989, p. 9) highlights that "the reading of the world precedes the reading of the word. Thus, the subsequent reading of the latter cannot dispense with the continuity of the reading of the former." This reading and understanding of the world allows students to develop their autonomy.

Krasilchik (2008) and Marandino, Selles, and Ferreira (2009) point to the importance of a dialogue between school content and students' daily lives, considering that, if there is no link between the first and the latter, school subjects will become irrelevant and meaningless, compromising meaningful, transformative learning. Siqueira and Guidotti (2017, p. 50) also share this thought. For the authors, one of the main objectives in the learning process is "to relate the contents covered at school with the students' practical life, bringing meaning to their learning and their performance as active citizens in society" (Siqueira and Guidotti, 2017, p. 50).

THE CULMINATION OF KNOWLEDGE: THE HEALTH FAIR

The knowledge gained from all previous stages was manifested and expressed during the culmination (moment 9).

The exhibition (Health Fair) included didactic models, maps, posters, video exhibitions, blood pressure measurement, weighing and calculation of body mass index (BMI), use of food, food packaging and labels, the installation of a fitness space, the dissemination of official health materials, among others. Students demonstrated an ability to communicate and disseminate knowledge using the most varied languages. They measured blood pressure and BMI and collected impressions from visitors.

The students showed proactivity by looking for partnerships and inviting a health professional to assist in measuring blood pressure. They also suggested contacting the Health Center, the Health Department, and the Blood Center, after obtaining information and dissemination materials to support their explanations.

It was possible to explore communication between peers and the community. The students interacted with visitors, answered questions from colleagues, were receptive and attentive, properly organized school time and space, and constantly invited the public to join in the work. Their satisfaction and pride for a job well done and their great desire to communicate with the visitors were very noticeable. They even held fellow students and teachers to stopping by.

The groups were free to choose their topic of interest and how they would present it. Interestingly, they all drew on Biology content to explain and reinforce their points. Students were also observed to rely on knowledge from other disciplines, expanding their resources and explanations. None of the groups was limited to one specific theme; rather, all the knowledge produced along the didactic sequence came to light.

For example, to talk about myocardial infarction, one group prepared a map showing its distribution in Brazil and explored the data from a socioeconomic point of view, comparing the regions of Brazil, and seeking explanations for the differences found between the South and the North/Northeast. Another group, addressing obesity, including childhood obesity, presented statistical data in graphics and infographics, and reflected on the situation in different countries and continents, seeking explanations in socioeconomic and cultural factors. Another group made a didactic model showing two lungs; when the plastic bottle was squeezed, only one of them inflated — the healthy one. This interaction with the visitor then moved on to a reflection on the integration of the whole body, with a demonstration of the impact of smoking on the cardiorespiratory system. What inspired this particular student was the fact that some of his relatives, who were heavy smokers, had died of cardiovascular disease. Another group, addressing healthy eating, relied on knowledge about nutrients and the digestive, locomotor, cardiorespiratory and nervous systems for their explanations. Thus, human physiology contents and interdisciplinary experiences were evoked to support and compose the work.

Siqueira and Guidotti (2017, p. 59-60) highlight that "school failure is directly linked to students' lack of motivation. It is of fundamental importance to have motivated students. The motivated human being overcomes his limits," and this was the main finding at the end of the Health Fair event. Students devoted themselves to research and investigation, constantly seeking to interpret and

relate data and information. They also made an effort to build their explanations autonomously, overcoming limitations through mutual support in groups and teacher mediation.

The Health Fair moment as the culminating event of the entire investigation was important to bring to students a feeling of belonging to the school, of scholarly and social inclusion. They felt valued individually and collectively as participants of the an EJA modality.

ANALYSIS OF THE QUESTIONNAIRES

The questionnaires were analyzed regarding:

- students' perception of learning, by assessing prior knowledge (pre-test) and acquired knowledge (post-test) for 14 specific topics;
- students' perception of the approach, by means of questions related to the applied methodology posed in the post-test questionnaire.

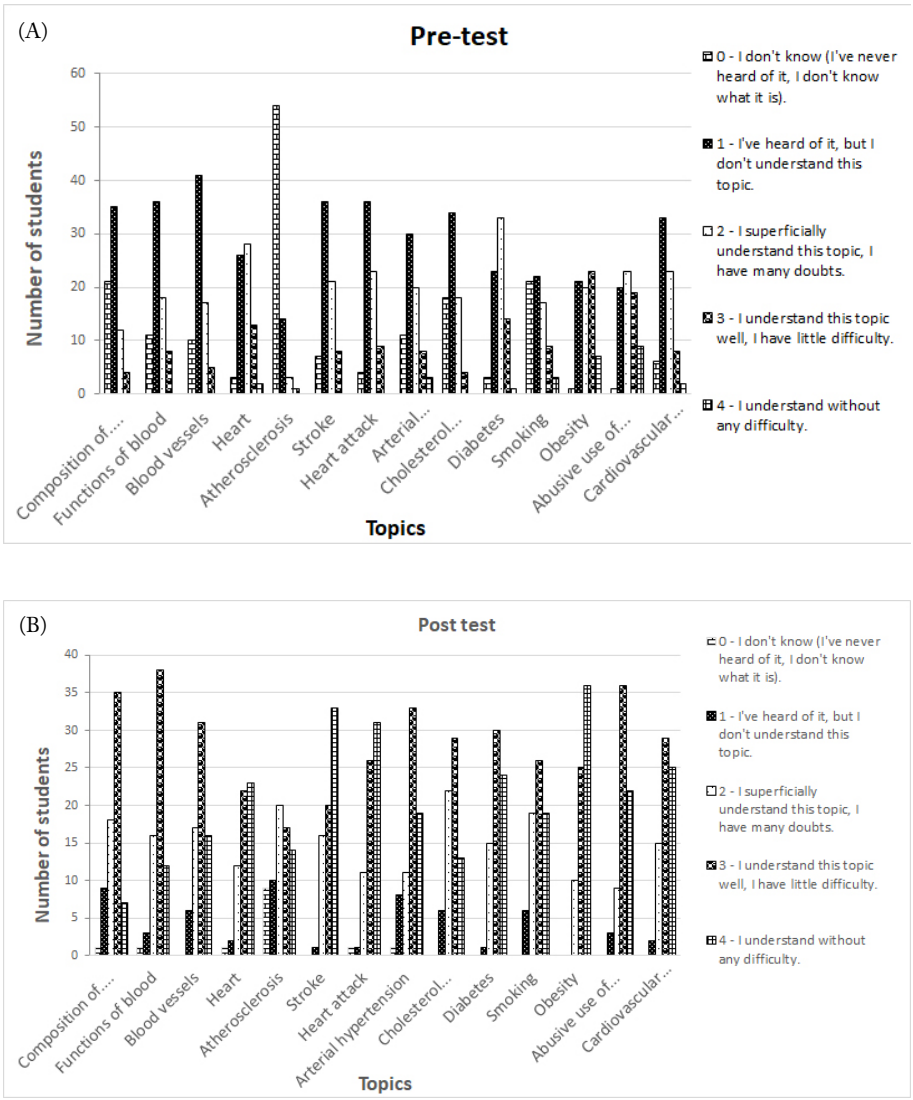
Learning perception

Analyzing the students' perception of knowledge/difficulty in the topics presented, the predominant answer in the pre-test was term 1 (*I've heard about it, but I don't understand this topic*), and, in the post-test, term 4 (*I understand without difficulty*) (Graph 1).

We believe the pre-test data show the students' daily relationship with the topics listed; they reveal more balanced values of knowledge/difficulty for conditions that are commonly found in the population, such as obesity and abusive use of alcohol — probably because there is more information about these conditions in the media, provided by the health systems. However, the balanced values found for terms 2 and 3 demonstrate that this knowledge does not dialogue with the other related themes, suggesting that there is still much to add to the students' prior knowledge.

Students chose a central theme to work with in their classrooms from the topics listed in question 1. However, the pre-test data were considered throughout the didactic sequence. With the investigative approach, we aimed to emphasize the interrelationship between all topics and stimulate the construction of individual and group explanations. We focused not only on those topics indicated as the most difficult but also on the best known. This policy aimed to lead the students to identify gaps and to be able to deepen and better elaborate their knowledge. The following statement demonstrates a student's perception in this regard: "*I saw topics I thought I had an idea of, but when I learned more, I realized that they are more complex than I had imagined*" (Student C13).

In the analysis of the results of the post-test questionnaire, terms 3 (*I understand this topic well, I have little difficulty*) and 4 (*I understand without difficulty*) predominated over all the topics listed (Graph 1B). In this comparison, a learning gain was perceived not only in the topics chosen for individual development in the classes (heart failure, blood composition, blood functions, cholesterol, atherosclerosis, and stroke) but also in the other topics. Knowledge increase after the inter-



Source: Santos (2020).

Graph 1 – Analysis of the answers to question 1, "How do you rate your knowledge and/or difficulty regarding the topics below?" in the pre-test (A) and post-test (B) questionnaires. Topics evaluated: blood composition, blood functions, blood vessels, heart, atherosclerosis, stroke, heart attack, high blood pressure, cholesterol/dyslipidemia, diabetes, smoking, obesity, alcohol abuse and cardiovascular diseases. Evaluated terms: 0 – I don't know (I've never heard of it, I don't know what it is); 1 – I've heard about it, but I don't understand this topic; 2 – I understand this topic superficially, I have many doubts; 3 – I understand this topic well, I have little difficulty; 4 – I understand without difficulty.

vention was statistically significant ($p < 0.01$), demonstrating the importance and merit of an investigative, contextualized, and integrated approach to the discussion of biological themes within the scope of EJA.

In such an approach, the integration of class content with the news, the search for explanations, the focus on the interrelation of topics during the process, and the presentation to the community at the Health Fair presented opportunities for students to advance in knowledge gradually. At each stage of the didactic sequence, more elements were added to the process of knowledge construction, which focused always on the investigative approach.

However, when the topics are viewed individually, only "Atherosclerosis" showed a balance between terms 3 and 4 in the post-test, considering all classes. The perception, nonetheless, of knowledge on this topic by the students that worked on it as a central theme improved. And there was a statistically significant knowledge gain, of 67%, for that topic. This is an expected result, compatible with the path taken. The perception of greater knowledge and less difficulty, by the students of the class, for the chosen topic, reflected a greater mastery of the subject, which was necessary to allow and promote knowledge exchange during the Health Fair.

This difference in individual learning gains per class meant a great deal for the presentation given during the Health Fair and the EJA students' individual appreciation and recognition.

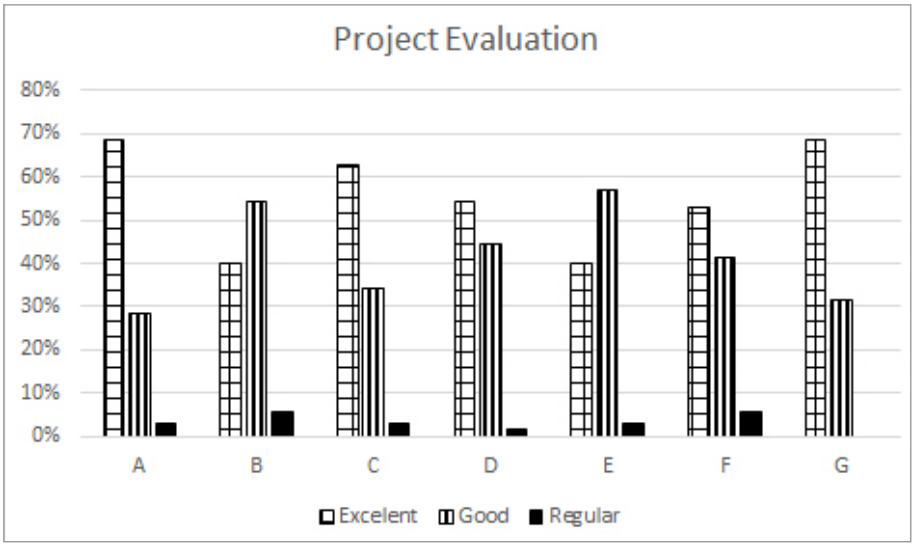
Finally, according to the students' perception, all of them advanced in all topics, even more so in their specific themes. This result can be attributed first and foremost to the investigative approach and the dissemination of knowledge, in addition to other aspects mentioned above. The investigation favored peer interaction, allowed the students to recognize themselves as subjects of their learning process and to move towards an autonomous construction of knowledge. Such a protagonist posture contributed to the development of self-esteem, giving students the confidence to present and disseminate the knowledge obtained. The exhibition was a motivational factor that stimulated the entire investigative process. The students envisioned the moment when they would share their knowledge, especially that in which they would have recognition and personal and collective appreciation as EJA students.

Approach perception

Question 2, present in the post-test questionnaire, verified the students' evaluative perception regarding aspects of the methodological approach used. The description of the evaluated items and the relative frequency of the answers are shown in Graph 2.

In general, the health project was positively evaluated by the participating students. In five of the seven items analyzed, the classification as excellent surpassed the sum of good and regular. Item G (*contribution of the project and Health Fair to the school community*) had the best overall evaluation, with 69% considering it excellent. The project's potential to reach the school community and its significance for the students thus become evident. The participants felt satisfied to have their friends and family in the school space and proud to present and exhibit what they had learned.

These results corroborate and correlate with those obtained in the perception of learning analysis presented and discussed above. The answer for item A (Graph 2) confirms and reinforces the close relationship established between the students and



Source: Santos (2020).

Graph 2 – Analysis of the answers to Question 2 in the post-test questionnaire. Values are given in absolute frequencies, representing the total value of the answers of all five EJA classes participating in the project. The items evaluated were: (A) overview of the project by the students; (B) their experience in developing and presenting Health-related work; (C) the project's contribution to their learning; (D) the impact of the project on their habits and reflections on their own health; (E) the inter-relation between school contents and daily life; (F) the contribution of other disciplines to the understanding of topics; (G) the contribution of the project and Health Fair to the school community.

the topics proposed, given that they were chosen based on a questionnaire applied in 2018. Item C reaffirms the positive advance in knowledge construction, hence in learning perception too.

The students identified with the subjects and contents covered in the project because they were part of their life context and had practical applicability in their daily lives. They became interested and participative in the teaching-learning process because the contents were meaningful for their reality. When a topic arouses interest, doubts, and restlessness, students are motivated to search for answers, assuming an autonomous and protagonist stance, since they recognize that knowledge as necessary and useful. In addition, the potential to apply this knowledge in their life context is increased. We believe this result was reached due to the consideration of students' perceptions and interests in the discipline (Krasilchik, 2008; Marandino, Selles and Ferreira, 2009; Carvalho, 2013; Siqueira and Guidotti, 2017).

As seen in the results for item D (*the impact of the project on students' habits and reflections on their own health*), participants found that the project contributed to fostering reflection and a change of attitude. The subjective data collected reinforce these results and allow a deeper understanding of this aspect.

For item B (*students' experience in developing and presenting Health-related work*), the task assigned to students was to organize, present, and exhibit their productions, ideas, and considerations. As already mentioned, this was the first experience of this type for many students. They showed difficulties and insecurity that were overcome through mutual support from the workgroups and the teachers'

mediation, both in conducting the didactic sequence and through support from other disciplines. During the exhibition, students experienced the acceptance and appreciation of visitors, gaining more confidence and self-esteem with each explanation.

While item A focused on the subjects and contents addressed in the project, item E did not. In the latter (*inter-relation between school contents and daily life*), there was no specification restricting assessment to the Biology discipline or the particular project developed. Thus, this item evaluated the school contents in general. Although it was classified as "good" by the majority, the low value of "excellent" (40%) points to the need to prioritize this inter-relation in planning and pedagogical practice, to advance towards excellence so that learning can become meaningful to students.

We must take into account, in item F (*the contribution of other disciplines to the understanding of topics*), that not all disciplines were involved, and interdisciplinarity was approached more specifically in some meetings. Still, the integration between disciplines was well evaluated by the participants. It is a challenge to plan contents and execute actions in an interconnected way, involving the whole teaching staff.

The students' perception proved to be in line with what is already being discussed in the education field. Although they do not have theoretical references on the subject, they judge empirically. Hence the importance of providing spaces for them to express their opinions, to be then taken into account in pedagogical planning and practice throughout the school year (Brasil, 2000; Krasilchik, 2008; Marandino, Selles and Ferreira, 2009; Brasil, 2012a; Carvalho, 2013).

CONCLUSION

After the didactic sequence was completed, we achieved our main objective, which was to stimulate protagonism, critical thinking, and student autonomy, equipping students for permanent learning.

We noticed this during data collection and analysis, which allowed us to verify and understand the students' impressions and considerations about the pedagogical strategy employed. Approximately 55% of the participants considered it as "excellent," among the seven aspects analyzed.

Students demonstrated motivation, protagonism, and autonomy for knowledge construction. They proved to have developed skills and abilities that facilitate permanent learning, with the potential to continue learning autonomously. We believe our focus on teaching by investigation was responsible for promoting such learning.

The data also indicate that the students' knowledge about cardiovascular diseases and their risk factors expanded. Contextualization, interdisciplinarity, and content integration stand out as the main contributing factors to the teaching-learning process in this specific case.

The students also revealed, in their perceptions and attitudes, the development of significant learning — verified in the post-test — as well as a potential to multiply knowledge by acting as health promoters and transformers of their own reality, such as they did with the Health Fair. Thus, they acquired remarkable tools for citizenship, demonstrating the competence to carry out individual and/or collective interventions regarding the determinants of the health/disease process.

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ABOUT THE AUTHORS

Monique Cesnik Martins dos Santos is a Master's student in Biology Teaching from the Universidade Federal da Paraíba (UFPB). She is a professor at the Education Departments of the state and municipality of João Pessoa (SEE-PB).
E-mail: moniquenikm@yahoo.com.br

Jefferson de Barros Batista has a master's degree in Biological Sciences from the Universidade Federal da Paraíba (UFPB). He is a professor at the Instituto Federal de Educação (IFPB).
E-mail: jefferson.batista@ifpb.edu.br

Maria de Fátima Camarotti has a doctorate in Biological Science from the Universidade Federal da Paraíba (UFPB). She is a professor at the same institution.
E-mail: fcamarotti@yahoo.com.br

Anabelle Camarotti de Lima Batista has a doctorate in Biotechnology from the Universidade Federal Rural de Pernambuco (UFRPE). She is a professor at the Universidade Federal da Paraíba (UFPB).
E-mail: bellecamarotti@gmail.com

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