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*RESEARCH ARTICLE*

# INVESTIGATIVE ACTIVITIES IN SCIENCE TEACHING: BREAKING BARRIERS IN THE LEARNING OF PHOTOSYNTHESIS.

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## *Abstract*

This study presents an active methodology for the teaching of photosynthesis developed during science classes and reports the process of applying investigative activities in a class of the sixth year of elementary education II, analyzing its impact on the previous knowledge of the students. The results obtained evoked a clear evolution in the conceptual profile of the students after the accomplishment of the investigative activities, however some evidences and conceptions are still relatively distant from the knowledge about the contemporary science. It was clearly perceived that students depend on the book to respond to the suggestions given in class, demonstrating a lack of autonomy in critical and reflective thinking. On the other hand, the students had a good participation in the discussions and showed themselves involved with the activity. These data point to the importance of a recursive approach to complex concepts such as photosynthesis throughout the schooling process. Thus, in spite of the difficulties encountered, it is considered possible and necessary the use of investigative activities in schools to favor, in addition to the development of abilities, the students' capacity for argument and possibility to develop more solid, critical and creative thoughts.



## Introduction:-

The teaching of science has been the subject of discussion among several authors as Bizzo (2009), Zanetic (1992) e Carvalho (1998, 2005, 2006), which have pointed out difficulties in the development of education, whether at the fundamental level or even at secondary level. One of the difficulties mentioned relates to the fact that the school

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does not provide students with the formation of a scientific culture that allows them to relate their knowledge to the scientific phenomena of daily life. This fact is related to the way in which teaching in this area of knowledge is organized, based on the memorization of concepts and with little, if any, student participation.

According to Arnoni, Borges and Koike (2005), most students see the science presented in the classroom as a discipline full of names, cycles and tables to be decorated, in short, a discipline where theory and practice are dissociated and decontextualized. So the question that arises is: how to attract students to study? and how to stimulate their interest and participation?, the answer, of course, is not simple and there is no ready recipe. The same author argues that for this question there can not be a universal formula, since each teaching situation is unique, but believes that it is necessary to seek solutions, such as planning the lesson, seeking motivating strategies, making use of a didactic resource appropriate, will certainly make the class more enjoyable and productive.

In order to overcome the difficulties left by traditional teaching, scholars in teaching in general, and in particular in the teaching of Natural Sciences, are increasingly exploring new methodological alternatives to facilitate and assist the teacher in the teaching- learning, valuing the use of various activities that encourage the student to have a scientific knowledge and search for it. Teaching Science through Research allows the teacher to have an innovative perspective, shifting the focus of class dynamics from a mere transmission of content. And by shifting the focus, the teacher enables the student to have a differentiated view of what science is and what a scientific inquiry is.

In this way, to develop activities that stimulate the students by the search of scientific knowledge, contributes in a significant way in the teaching-learning process. Thus, the study aimed to evaluate the contribution of research activities in the learning process of elementary students II, through the construction of their knowledge about photosynthesis.

**Theoretical foundation**

The teaching of science should provide learners with a set of knowledge, which enables the formation of a culture and not only an accumulation of meaningless names and formulas, as discussed by Zanetic (1992), Bizzo (2009), Carvalho (2006 and 2013) , Capecchi (2013) and Sasseron (2013), propose a science education based on research, starting from a problem that establishes discursive interactions between teacher and students and students with their peers in the construction of scientific knowledge.

According to Capechi (2013), it is necessary that the teachers propose to their students a different look at the situations that they usually experience in the daily life. he construction of this look involves from the presentation of situations-problems, challenges, to the aid in its interpretation. Problematize is to formulate problems different from those students are accustomed to elaborate in order to provide opportunities for new knowledge to be built.

The photosynthesis theme for the teaching of science makes possible a knowledge about the mechanisms and life cycles of living beings, their relationship with the food chains and the metabolism of energy for life.

Photosynthesis involves many physiological processes, is the source of plant life through autotrophic nutrition and energy source for the food chain. His understanding involves several scientific areas such as: ecology, physiology, biochemistry, chemistry and physics. The teaching of photosynthesis aims at the knowledge of the study of energy metabolism, as well as all the structures that facilitate its realization. The individual in coming into contact with this content should differentiate the photosynthesis of the breath. Photosynthesis is the opposite of breathing. Plants breathe and photosynthesize, while photosynthesis is a food producer respiration is a producer of energy. The majority of the students upon their arrival bring in their baggage of knowledge faulty concepts on the subject of photosynthesis (NEUMANN, 2013).

The teaching of the 'photosynthesis' content has been reported in the literature (MORTIMER, 1996; AZEVEDO, 2004; ALMEIDA, 2005; CACHAPUZ, 2005; CORDEIRO, 2010) and there have been difficulties in this teaching, revealing numerous student conceptions, accepted by the scientific community. These conceptions make it difficult to understand the importance of photosynthesis as a process of food synthesis. Souza and Almeida (2002) showed that several authors verified that students do not understand how and why water, air and sunlight are used in food production.

According to Kawasaki and Bizzo (2000) "By requiring knowledge from different areas, the study of photosynthesis allows a creative exploration that integrates different knowledge from different disciplines". The student arrives with an incorrect knowledge about plant nutrition, making it clear that the plant feeds on water and nutrients that suck from the soil. It often relates carbon dioxide as a source of respiration and the release of oxygen as a result of this breathing. In this sense, the understanding of the basic concepts of the biological sciences is central to the learning of biological phenomena, and, in addition, to other areas of knowledge such as Physics and Chemistry.

Consequently, the subject of photosynthesis involves fundamental concepts for the teaching of sciences, allowing a comprehensive view of the mechanisms and life cycles of living beings, as well as their relations in the food chain, evolution, energy metabolism, among others. It is necessary, therefore, to reflect on methodological strategies that favor the teaching and learning of fundamental concepts, such as the subject of photosynthesis, which are considered confusing and complex by students (CAÑAL, 2005; SOUZA and ALMEIDA, 2002). In addition, the lack of content of these subjects that accumulates since elementary school I (MEDEIROS, 2007; BONZANINI and BASTOS, 2004), points to the distance between the school reality and the disciplinary curriculum.

According to Moreira and Masini (1982), there are two types of learning: meaning and mechanics. In meaningful learning, we have a process by which a new knowledge relates to the cognitive structure of the subject in a substantive rather than arbitrary way. Whereas, mechanical learning relates the new information to the cognitive structure in a non-substantive and arbitrary way.

Significant learning and mechanics are not dichotomous or antagonistic, but are at opposite ends of a continuum. It is this process that characterizes the learning process and, therefore, the advancement in the continuum between mechanical learning and meaningful learning (LEMOS, 2008; MOREIRA, 1999). Finally, teaching should be planned in order to facilitate meaningful learning through a potentially significant procedure that takes into account: the nature of prior knowledge; the information to be learned, the presence of adequate subsunitions in the cognitive structure for the anchoring of new knowledge; and the intentionality of the student to learn meaningfully (LEMOS, 2005; MOREIRA et al., 2004).

In this way, the teacher should seek alternative methodologies that facilitate the assimilation of students' knowledge, among which one can cite experimental research activities. In this sense, the research activities are of great importance, since it arouses the interest of the student, since, the experiments prove the hypotheses studied in the theoretical scope and will encourage the search for the scientific knowledge about the theme contemplated in the classroom.

## Methodology:-

The study was carried out in the class of the 6th year of elementary school II, of a school in the city of Chã Grande-PE, during the science class in the first semester of the 2018 school year. Two classes (45 minutes each) were used to understand the theme. The research was of qualitative character and activities of interventions in the classroom were carried out.

The subject proposed by this study is included in the Photosynthesis content, in view of this at the beginning of the class, were raised problematizations such as: What do plants feed? What is photosynthesis? How do plants use gases and solar energy in this process? How does breathing occur? What is the difference between photosynthesis and respiration? How do plants use the products of photosynthesis in plant nutrition? How important is the process of photosynthesis to living things and to the planet?

After these questions, it was possible to observe difficulties of the students in relation to the phenomenon Photosynthesis, since, this is a complex process that generates several doubts in the students.

After the class was divided into groups so that they could perform the experiment of pigment extraction, this practical activity was conducted according to the following steps: 1) Cut the leaves and macerate with pestle until all the leaves are in small pieces; 2) Place the macerated sheets in the glass containers together with the chosen solvents (Acetone, alcohol, etc.); 3) Then put the strips of paper in contact with the solvent and wait for the solvent to rise to the end; 4) Wait to dry and observe how the pigments have spread on the filter paper.

During the interval of the experiment the student groups were asked to formulate hypotheses of what could happen in the experiment with their explanations. Every process was mediated by the teacher. After completing the experiment they excluded or confirmed their hypotheses. The students were evaluated continuously observing the quality of their teaching-learning and how the accomplishment of this experimental activity contributed to the acquisition of scientific knowledge.

In the next class the students produced a questionnaire and interviewed each other, so that all together they could make an analysis of the results obtained through the questionnaire.

## Results and discussion:-

The questions raised during the lesson were very pertinent, since it allowed to observe the previous knowledge of the students and what their difficulty in relation to the topic photosynthesis. In this intervention, it was observed that the students presented many difficulties in answering the questions and even in elaborating answers to the listed questions.

Some answers to this prior knowledge are quoted below:

**Question 1: What do plants feed on?**
Student 1: "I think they feed on light."
Student 2: "They feed on land and water, the sun serves to warm it up."
Student 3: "They do not need food."

**Question 2: What is photosynthesis?**
Student 1: "It's when the sun enters the plant".
Student 2: "It is when the plant picks up water from the soil".
Student 3: "It serves to breathe the plant".

**Question 3: How do plants use gases and solar energy in this process?**
Student 1: "Plants do not need oxygen".
Student 2: "When the wind hits the plant it picks up the air and uses it".
Student 3: "The plant only uses the gases when it breathes".

**Question 4: What is the difference between photosynthesis and respiration?**
Student 1: "In accurate photosynthesis of the sun and in breath do not need".
Student 2: "Photosynthesis only has daylight and breath only at night".
Student 3: "In the breath there is only oxygen".

Most of the students showed difficulty in the correct differentiation of photosynthesis and respiration processes. Most of the students showed difficulty in the correct differentiation of photosynthesis and respiration processes. At this point, it became evident that the students are not clear about the differences between these two concepts, since about 60% of the class considers that the plant breathes the carbon dioxide and releases the oxygen in both processes.

The conceptions exemplified above can be classified as "realistic" in relation to the conceptual profile of Mortimer (1996), since they begin from the common sense, from the recognition of the importance of these processes for the vegetables, so that these students can not correctly correlate the role of these elements in plant metabolism.

The questions asked were intended to lead the students to understand that the plant, like any living being, breathes. In addition, they were used for students to understand that the plant, besides breathing, also performs photosynthesis, these being different processes.

The initial intervention was considered to be significant from the point of view of teaching-learning, because it highlights important information for the teacher about the students' previous conceptions.

**The hypotheses formulated by the groups are described below:**
Group 1: The paper will change color.
Group 2: The liquid will freeze.
Group 3: The paper will be filled with chlorophyll.
Group 4: The liquid will rise and wet the entire paper.

The answers show that students have a fair idea of what would happen in the experiment. However, the data also confirm the lack of autonomy to construct broader hypotheses and according to the content given. In this way, teaching situations need to provide students with conditions that stimulate a broader way of thinking, with greater reflection on certain phenomena besides encouraging them to present their ideas (ZÔMPERO and LABURÚ, 2012).

Throughout the experiment, the students were interested, actively participating in the research activity, verifying that there was a relation of their previous knowledge and scientific knowledge, which made possible the construction of a critical reasoning to develop their conclusions about the proposed theme. In addition, during the experiment, some groups questioned what would happen if they mixed the pigment extracted from the green leaf and the red flower? Would the same phenomenon happen? and so was the observation test.

In the following class, the same groups prepared a questionnaire and exchanged with each other to discuss the experiment and how this is related to the phenomenon of photosynthesis and respiration. Some questions asked by the students themselves after the experimental activity and their respective answers are described below:

**Question 1: How do plants produce their own food?**
Student 1: "The plant needs the sun and water together to produce its food".
Student 2: "Terrestrial plants use sunlight to make photosynthesis and use oxygen and carbon dioxide to produce their food".
Student 3: "Light helps water enter the plants ... and produce its food".

**Question 2: What is produced in photosynthesis?**
Student 1: "Oxygen is produced that goes into the air and sugar that is in the plant".
Student 2: "The plant produces glucose which is a sugar for food".
Student 3: "Plants produce energy, sugar and oxygen".

**Question 3: How does breathing occur?**
Student 1: "Plants breathe oxygen and release carbon dioxide".
Student 2: "During the day the plants breathe little and at night they breathe more".
Student 3: "All plants do the opposite of photosynthesis, take oxygen from the air and throw carbon dioxide into the environment".

Through targeted discussion, students were able to understand which hypotheses were appropriate and how their thinking changed on these phenomena, when compared to their knowledge before the investigative activity. It was observed that the investigated students managed to "evolve" in the conceptual profile, so that, after carrying out the investigative activity, their conceptions assumed an "empiricist" character, which is explicit in the student's response

"The plant needs the sun and water together to produce their own food". In addition, it was demonstrated that there was an interdisciplinarity in obtaining the knowledge of the topic photosynthesis, being related the contents of chemistry and biology.

In his study Almeida (2005) emphasizes the importance of relating evolutionary, ecological and physiological aspects in the teaching of photosynthesis, demonstrating that this process involves much more than chemical reactions and memorization of formulas, as transcribed below:

(...) On the other hand, to the detailed and mnemonic approach of the scientific terminology created to describe the process, especially in high school, neglecting to understand its fundamental organic aspects from the physiological, ecological and evolutionary point of view, as well as of cognitive-affective regulation by students of their personal and collective process of constructing the notion of photosynthesis. In both cases, thinking is satisfied only with the verbal agreement of definitions, more or less profound, immobilizing (ALMEIDA, 2005, p.30-31).

In view of this, the teaching of photosynthesis should be approached contemplating the contributions of the three areas of Natural Sciences (Biology, Chemistry and Physics), because if these areas are not correlated, the student can present a fragmented understanding of the phenomenon, according to the research has shown.

In addition, it can be verified that during the investigative activity, the students presented the characteristics of inquiry activities described by Bybee (2006) that were the involvement in the proposed activity, formulation of explanations about the evidence, articulation with the scientific knowledge and communication of the explanations. According to Zompeiro, Gonçalves and Laburí (2017) this methodology besides learning also provides the development of skills such as observation, comparison, recording and data analysis.

**Final considerations**

The research activity revealed a significant difference in the students' previous knowledge with the knowledge acquired after the pedagogical intervention. The research activity was of great importance for the teaching-learning of sciences, favoring the participation, cooperation, proposition of hypotheses, observation and debate of ideas, which consequently evidenced the quality and the assimilation of students' understanding of photosynthesis, correlated their everyday practices with scientific knowledge.

The use of investigative activities has a prominent place in the classroom, especially when these activities can be multidisciplinary, approaching other disciplines such as physics and chemistry, which enables the student to reflect scientifically, valuing the search for knowledge.

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