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Science Teaching by Inquiry: Indicators of Scientific Literacy in distance classes

Ensino de Ciências por investigação: indicadores da Alfabetização Científica em aulas a distância

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A B S T R A C T

This article aims to analyze which investigative practices emerged in a forum of the discipline "Knowledge and methodology of science teaching 1" (*Saberes e metodologia do ensino de Ciências 1*) of a Pedagogy distance learning course. As an activity it was proposed that the students solve the question "investigating the problem of Jeca Tatu". From the qualitative research and content analysis of Bardin (2011), elements of investigative practice were identified in the students arguments, such as: hypotheses, hypothesis testing, data, production and defense of arguments and explanations. Thus, it was inferred that, as long as they have a question with scope for collective problematization and the (re)construction of students cognitive actions, investigative activities are totally plausible to be successfully worked on in distance science classes.

R E S U M O

O presente artigo tem como objetivo analisar quais práticas investigativas surgiram em um fórum da disciplina "Saberes e metodologia do ensino de Ciências 1" de um curso de Pedagogia a distância. Como atividade foi proposto que os discentes resolvessem a questão "investigando o problema do Jeca Tatu". A partir da pesquisa qualitativa e da análise de conteúdo de Bardin (2011), foram identificados nos argumentos dos estudantes elementos da prática investigativa, a exemplo: hipóteses, teste de hipóteses, dados, produção e defesa de argumentos e explicações. Desse modo, inferiu-se que, desde que tenham uma questão com margem à problematização coletiva e à (re)construção das ações cognitivas dos estudantes, atividades investigativas são totalmente plausíveis de serem trabalhadas exitosamente em aulas de Ciências a distância.

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Introduction

The National Common Curricular Base (*Base Nacional Comum Curricular* - BNCC) (2017) pointed to teaching by investigation as a theoretical assumption of science teaching in basic education. Before this document, the teaching of Sciences by investigation was already pointed out by researchers in the area as a didactic approach that generates in the classrooms the opportunity to learn a living Science, endowed with elements that encourage the student to learn to learn by research, by the active action of thinking, of building strategies and action plans.

By providing the student with the possibility of seeing these plans being tested, in order to reflect on what worked or not, by having the opportunity to discuss with his peers his thoughts and to assert his curiosity about the phenomena of the world, in the eyes of any teacher who seeks an education in constructivist strands, the teaching of Science by research gains importance. Although the teaching of Science by investigation gains space in the lesson plans of this teacher profile, it´s not uncommon to mistake this didactic approach.

One of these misconceptions is to associate the teaching of Sciences by investigation only to practical activities, those in which students necessarily have access to materials for manipulation (MUNFORD, LIMA, 2016). As Carvalho (2013) points out, the teaching of Sciences by investigation can be worked with this type of material, as well as it can be carried out through photos, texts, tables and graphs, that is, materials not necessarily experimental.

It´s from this thought that we propose to investigate which investigative practices emerged in a forum of the discipline "Knowledge and methodology of science teaching 1" (*Saberes e metodologia do ensino de Ciências 1*) of a distance Pedagogy course. From a non-experimental activity, we obtained results that indicate that in the face of well-posed problems, that is, problems that give rise to the production of data, evidence, hypotheses and confirmation of them in different sources of knowledge, the teaching of Sciences by investigation is plausible in distance classes.

Development

The teaching of Sciences by investigation is a teaching practice that leads the subject to learn Sciences immersed in the scientific culture. This means, that far from opening the textbook and carefully following the reasoning presented by the teacher, the student is invited to make use of his **expertise** to learn Science by the construction and testing of hypotheses, by acting and reacting to the effects of his actions and ideas (CARVALHO, 1998).

To learn Science by investigation is to be inserted in an organizational culture in which the protagonism of the student happens naturally, so that he is not afraid to make mistakes, to expose his ideas and see them in action by the collectivity of the classroom. To learn Science

by investigation is to have the possibility of seeing and understanding that we experience Science from the moment we sleep until we awaken, it´s to understand that we are also Sciences.

Therefore, learning Science by investigation is to understand the meaning of concepts and be able to contextualize them to the phenomena that happen in our daily lives. It´s still to remove the esdrúxula cover of scientific concepts, in order to use them as a vehicle for arguments, which well contextualized promote changes in problems involving Science and Society.

It should be noted that there is a tendency among teachers to understand the teaching of Science by investigation as purely practical activities, in which the student must necessarily manipulate objects. Like Campos and Nigro (1998), we affirm that this is a misconception.

There are different possibilities to propose investigative activities, as Carvalho (2013) shows, these activities can be worked from manipulative materials, to photos, texts and ideas brought by students. The central point of this type of activity is the proposition of a problem that serves as an engine for the development of ideas to be worked collectively by hypotheses and hypothesis testing, by the production of evidence that makes learning a process of experiences, that is, of means of different problem resolutions and construction of thought.

Given the multimodality of working the teaching of Sciences by investigation, we highlight that Carvalho (2013) considers three types of problems: Experimental problem, investigative demonstrations and non-experimental or theoretical problems. **Experimental problems** are those that involve the physical manipulation of the objects involved in an investigation.

The materials of this type of practice should be organized in such a way that allows students to diversify their actions to as soon as they realize that their variation causes a direct change in the reaction of the objects. These actions of the students and reactions of the objects constitute an exponential factor for the student to allow himself to make an error and from it structure coherent reasoning.

There is talk of **investigative demonstrations**, when the experimental apparatuses, for various reasons, (dangerous objects, limited material, etc.) are manipulated by the teacher, the students, in this case, enjoy the activity. The fact that this type of experimental problem does not provide opportunities for the direct physical action of students on objects does not mean that one should attenuate typically mental faculties, for example: creation and testing of hypotheses, reflection on data and evidence.

In other words, for this type of problem to have connotation of an investigative situation, the teacher must encourage students to participate in the actions of the activity. The teacher must ask questions so that the students express themselves, engage intellectually in order to create strategies to be carried out by the teacher.

Still on problem types, Carvalho (2013) makes reference to **non-experimental problems**. These didactic constructions transform materials such as: figure, images, texts, graphics and ideas of the students themselves into investigative situations. What characterizes problems of this nature is a good question, which directs the student to work with hypotheses, data, evidence, arguments.

Therefore, it´s advisable for the teacher to reflect on the objectives and strategies immersed in the activities he plans. If the proposal is limited only to the contemplation and execution of steps of an experimental guide, it will not have investigative characteristics; if it allows to overcome these contours, if attending to thinking hypothetically, to systematizing data, to discussing evidence, to reflecting on the error and to the collective appreciation of inferences, the activity will certainly be immersed in the practices of Science teaching by investigation and Scientific Literacy.

About Scientific Literacy, we highlight that it´s a process that by its characteristics aligns with the purposes of science teaching by investigation. It´s so much so that to analyze whether students are walking within the objectives of Scientific Literacy, Sasseron and Carvalho (2008) proposed indicators characteristic of investigative practice, for example: construction and testing of hypotheses, comparison of data and conclusions.

About Scientific Literacy, we emphasize that it´s a process that makes the subject able to read, understand and signify the phenomena of the world in an argued and critical way. This ability becomes possible as students experience practices, procedures and social discussions that involve Science and society.

Methodological path

Taking into account the theoretical foundations of Marconi and Lakatos (2006), we carried out the present research under the foundations of the qualitative approach. About this type of research "[...] aims to express the meaning of the phenomena of the social world" (NEVES, 2007, p. 01).

With a view to this approach, we carried out the present study from the offer of the discipline "Knowledge and methodology of Science Teaching 1" (*Saberes e metodologia do Ensino de Ciências 1*) in a course of Distance Pedagogy. The referred curricular component has 60 hours and in addition to being taught through the virtual environment Moodle has two moments of face-to-face classes.

The syllabus of the discipline is marked by themes aligned with the BNCC (2017), such as Scientific Literacy and Science teaching by research. For this reason, one of the activities planned by the teacher of the discipline aimed to involve the students, in asynchronous activities, with investigative practices.

This activity is the object of analysis of the present study and was developed in a forum on Moodle. In the said forum, the students had to solve a question called "investigating the

problem of Jeca Tatu". As a *corpus* of the research, we used the arguments produced by 22 students in this activity.

We seek to answer the following question: **What investigative practices emerged in a forum of the discipline "Knowledge and methodology of science teaching 1" (*Saberes e metodologia do ensino de Ciências 1*) of a distance learning Pedagogy course?** To this end, we adapted an activity proposed by Zomperu and Laburu (2016) for students of a distance learning Pedagogy course at the Federal University of Alagoas (*Universidade Federal de Alagoas* - UFAL).

This activity has as didactic material a fragment of the book short story Urupês by Monteiro Lobato, in the activity students are encouraged to investigate the disease of Jeca Tatu.

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> The following is the context of the problematic activity:
>
> > Jeca Tatu was a poor *caboclo* who lived in the woods, in a small house of sapé. He lived in the greatest poverty in the company of his wife, very thin and ugly, and of several pale and sad children... Jeca Tatu was so weak that when he went to wood he came with a bundle that seemed like a joke. And it came arched, as if it were carrying an enormous weight [...] one day a doctor carried it there because of the rain and was amazed by so much misery. Seeing the *caboclo* so yellow (pale) and weak, he decided to examine it. 'Friend Jeca, what you have is disease'. (fragments of Monteiro Lobato's short story, published in the book Urupês in 1918).

From the doctor's diagnosis, the Pedagogy students had the task of investigating the causes, symptoms and preventions of Jeca Tatu's disease. To do so, students should identify data, work with variables as a way to support the construction of reasoning, raise and test hypotheses and develop explanations, having as a guarantee these actions of scientific practice. To resolve this issue, in a forum on Moodle called "investigative actions in focus" (*ações investigativas em foco*) groups of five students were formed.

After the resolution of the problem, the students should report in the forum "investigating the problem of Jeca Tatu" (*investigando o problema do Jeca Tatu*) what they did to solve the case and what conclusions were reached. These reports served as a research *corpus* and were interpreted by Bardin's (2011) content analysis.

This form of data analysis is a set of interpretive techniques that help the researcher to describe and decode the meaning of the situation studied. Making use of the reading of the texts produced in the forum "Investigating the problem of Jeca Tatu", we proceeded with the cutting and classification of the data into categories that demonstrated indicators of Scientific Literacy.

In the present study, we present only two fragments of each constructed category. The frequencies of all indicators of Scientific Literacy, which appeared in the analyzed texts, are presented in a graph. The overview of which indicators appeared more or less frequently was unique to arrive at the findings of the present study.

Presentation of data

Next, we present the categories that were constructed through data treatment and analysis.

Data identification

The serialization of information [...] "does not necessarily foresee an order to be established, but it can be a roll of data, a list of data worked" (SASSERON; CARVALHO, 2008, p. 338). According to the authors, the elements involved in the data serialization arise at times when bases for investigative action are planned.

In this sense, in the following ideas, presented with fictitious names, it´s possible to characterize the identification of data by students, let's see:

Paula:[...] "He was tired, weak, discouraged... yellowish skin, pale, weakness, the house was simple, there was probably no bathroom".

Roberta: [...] "Regarding the clues left many doubts if Jeca would have verminoses or anemia, because, verminoses are diseases caused by the presence of parasites in the body, which can cause constant abdominal pain, feeling of swollen belly and changes in appetite and these symptoms are not mentioned in the history of Jeca. Nevertheless, anemia is the result of the lack of red blood cells in the blood that causes the reduction of oxygen flow to the organs, leading the individual to feel fatigue, vertigo, pallor and these symptoms are mentioned in the history of Jeca Tatu".

Elaboration of hypotheses

About the hypothesis survey, it´s understood that [...] "It points out moments when assumptions are made about a certain topic. This survey of hypotheses can arise either in the form of a statement or as a question" (SASSERON; CARVALHO, 2008, p. 339). These assumptions are noted in the following arguments:

Fábio: [...] "The lack of proper sanitary conditions, associated with his custom of walking barefoot certainly made him contract the disease that is acquired through the entrances of the skin that come into contact with the parasites of the feces".

Roberta:[...] "The group raised two hypotheses, firstly that Jeca would be suffering from anemia, since, he presents a constant weakness and an excessive discouragement that barely had the strength to carry firewood and much less animation to plant 'kale' for example which is a vegetable rich in iron, which in this case would help in the treatment of anemia.

Secondly, the hypothesis was raised that Jeca would have worms as already mentioned by the large group, due to the poor hygiene conditions in which Jeca lived".

Hypothesis testing

The hypothesis test [...] "Concerns the stages in which the assumptions previously raised are put to the test. It can occur both in the face of the direct manipulation of objects and at the level of ideas" (SASSERON; CARVALHO, 2008, p. 339). These characteristics can be observed in the following propositions:

Luana: [...] "The disease can also be popularly known as 'yellowing' (*amarelão*), as being an intestinal parasite of the types Amebiasis (amoeba) Giardiasis (giardia Hookworm) (yellowing) etc., this hypothesis arises because 'yellowing' is characterized by anemia, diarrhea, malaise and fever, symptoms precisely of Jeca".

Joana: [...] "To reach a conclusion about which disease Jeca would have, we researched the topics: verminosis and anemia on internet sites. That's when we realized what types of worms can cause anemia itself".

Elaboration of explanations

About the survey of explanations [...] "It arises when one seeks to relate information and hypotheses already raised" (SASSERON; CARVALHO, 2008, p. 339). These relationships can be identified in the following ideas:

Barbára: [...] "And it was then that we understood that Jeca Tatu is with anemia from verminosis, more precisely hookworm, better known as 'Big Yellow', this worm, caused by the *Ancilostoma Duodenale* and the *Necatoramericanus*, lives in the small intestine, feeds on blood causing anemia."

Flávia: [...] "Seeking an elucidation we conducted a research on the cause and symptoms of the same, coming to the conclusion that Jeca has anemia due to verminosis, hookworm or yellowing".

Science and society/Articulating ideas

The articulation of ideas [...] "arises when the student establishes relationships, either orally or in writing, between the theoretical knowledge learned in the classroom, the reality lived and the environment in which he is inserted" (PIZARRO, 2015, p. 234). This indicator of Scientific Literacy is visible in the following ideas, expounded by the students:

Ana: [...] "Although the incidence of so-called neglected diseases presents decreasing rates in the country, Brazil still lives with a significant number of cases of these diseases. Low-quality buildings, open sewage and daily contact with unhygienic environments are situations that leave the population more vulnerable to diseases such as schistosomiasis and diarrhea".

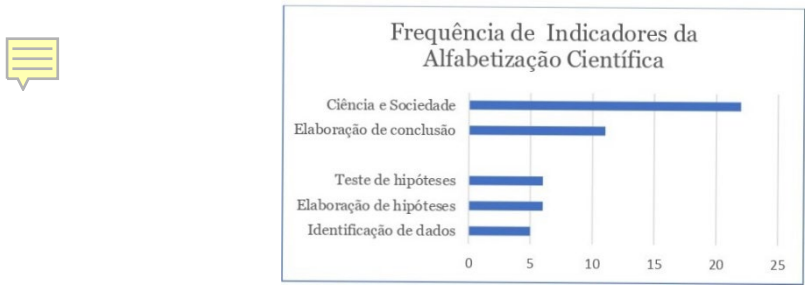
Cláudia: [...] "The problem of misery, scarcity of goods and services in which a large portion of the Brazilian population lives is a glaring and current problem. Unfortunately our representatives do not do their part and we do not charge for our rights. We live in a situation similar to that of Jeca, structured in a commodity, in the comfort zone that we ourselves have created".

Results

To discuss the results, we present the following graph:

Figure 1.

Frequency of Scientific Literacy Indicators.



Source: Author's data.

We treated and analyzed 22 texts of the forum "Investigating the problem of Jeca Tatu". The graph in question shows that the indicator "**Science and Society**" was the one that most emerged in the placements of Pedagogy students. This indicator appeared in arguments that highlight the apathy of the population in the face of the terrible conditions of health, food and basic sanitation.

More broadly, this score was associated with poverty, lack of access to public health and education. Among the indicators of Pizarro (2015) there is one called "Acting". This indicator is fully contextualized to the discussions on Science and Society, since it´s characterized by the citizen position of acting as an agent of change in the midst of social problems.

This ideal of the subject appeared at times when students associated poverty and lack of education with the poor quality of life of the population. The idea of a transforming man in his environment was also clear when the students pointed out the need to occupy public spaces to denounce and claim the situation of the population, which is still affected by health problems resulting from the terrible living conditions.

Regarding the indicator "**data identification**" it´s observed that it had 5 occurrences, that is almost 23% of the texts analyzed. This indicates that most students did not seek to solve the problem from this element of investigative practice in a structured way. It´s worth mentioning that although the identification of data was not made explicit, in order to highlight

which data supported the investigation, the students even scored these elements, but this occurred unintentionally, that is, it occurred diluted in the explanations of the subject themselves, without a problem that made explicit the research methodology adopted.

About the "**Construction of hypotheses**", it´s perceived that it had 6 frequencies and as can be observed in the category "Elaboration of hypotheses" these constructions appeared supported by words that express assumptions, such as the placement of Fábio: "The lack of adequate sanitary conditions, associated with his custom of walking barefoot **certainly** caused him to contract the disease that is acquired through the entrances of the skin".

It´s observed that the assumptions (hypotheses) raised by the students passed through the sieve of the "**hypothesis test**". This category also had 6 occurrences, which points to the need to investigate the hypotheses constructed in the investigation. It´s noted in the category "**Hypothesis Survey**" that the students constructions were tested by identifying the symptoms of the character Jeca Tatu. To understand these symptoms, the students resorted to an internet search. Let's look at the following excerpt: "To reach a conclusion about what disease Jeca would have, we researched the topics: Verminosis and anemia on internet sites. That's when we realized what types of worms can cause anemia itself" (ROBERTA).

We highlight that the indicator "**Elaboration of conclusion**" had 11 occurrences, that is, 50% of the texts analyzed. To discuss this indicator, we seek support in the thought of Bachelard (1938), when he emphasizes that there are in schools reckless rationalizations based on a culture in which the answers are much more considered than the questions themselves.

We understand that this culture of responses constitutes a factor of inertia to investigative practices, since it contributes to the subject in the process of knowing value more confirmations than what contradicts him. It´s with this thought of Bachelard (1938) that we understand that, although the indicator "**Elaboration of conclusion**" had half of the scores analyzed, it does not mean that all of them were properly constructed based on the practices of the investigation.

This means that some of the conclusions produced by the students were simply information reproduced from websites, without a constructive, dialogical, contradictory and problematic process of research in Sciences. This statement is constructed because the indicators "hypothesis elaboration", hypothesis testing and data identification, for example, appeared in less than half of the analyzed texts.

We understand the absence of these elements as a sign that the students did not engage in a constructive learning process, or in the words of Bachelard (1938) put weight on the answer and did not pay attention to the nuances of the question and the learning that could come from it. Thus, it´s by understanding that [...] "all knowledge is the answer to a question. If there is no question, there can be no scientific knowledge. Nothing is obvious. Nothing is free. Everything is built". (BACHELARD, 1938, p. 18) that we consider that only 27% of the

texts present what Sasseron and Carvalho (2008) call relations of information and hypotheses to build conclusions.

Final considerations

The aim of the present study was to analyze which investigative practices emerged in a forum of the discipline “Knowledge and methodology of science teaching 1” of a distance learning pedagogy course. Therefore, in order to meet the characteristics of distance classes, we adapted an activity proposed by Zomperu and Laburu (2016). This activity is a fragment taken from the book short story *Urupês* by Monteiro Lobato.

Through the Moodle platform, specifically in a discussion forum, the activity was initially worked on in teams of five students, later, with the whole group, the students presented how the problem was solved. Making use of Bardin's (2011) content analysis, we structured categories that indicated to us that students have a tendency to relate the content studied to the reality experienced. The frequency of the indicator “Relation Science and Society/acting” indicates this question.

We understand that by the characteristic of the Pedagogy course (by the menus of the various curricular components) this category “Science and Society Relationship” is a discussion that is an object of transversal learning, that is, it´s about concepts and values related to citizenship and democracy that permeate the objectives and purposes of each discipline and that globally result in the whole course. Because it permeates all areas of knowledge, the category “Relation Science and Society” becomes a tonic in the scores of the subjects investigated.

We also conclude that most students construct explanations about the content involved in the problem, but these explanations are not carried out from procedural contents characteristic of research in Sciences: Survey and testing of hypotheses, comparison, production of data and evidence and sharing of results. This means that students still value the culture of the answer over the question.

Even in the face of this evidence, which shows that students need to have more contact with this type of class, we consider that the investigative activity of the present study generated results that indicate that in the face of well-posed problems, that is, problems that give rise to the production of data, evidence, hypotheses and confirmation of them in different sources of knowledge, science teaching by research is plausible in distance learning. This inference is based on the elements of scientific investigation, which even at a lower frequency than the indicator “relation Science and Society / Acting,” emerged qualitatively in the propositions of part of the students.

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