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African Journal of History and Culture

September 2018
ISSN: 2141-6672
DOI: 10.5897/AJHC
www.academicjournals.org

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Vol. 10(6), pp. 67-76, September 2018
DOI: 10.5897/AJHC2018.0412
Article Number: 8BAAE0B58874
ISSN: 2141-6672

http://www.academicjournals.org/AJHC

African Journal of History and Culture

Full Length Research Paper

The use of the History of Science to improve the understanding of the thematic of reproduction: A study with students of secondary school

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Received 5 July, 2018; Accepted 11 September, 2018

The History of Biology teaching offers immense advantages in students' success, this fact being supported by many authors. This study mainly aims to identify the knowledge of the sample students about the reproduction of living beings. A qualitative methodology and questionnaire were used to collect data. The sample consists of 18 students from a secondary school, in North Portugal. For comparison, the same questionnaire was applied to another class under the same conditions, to ascertain the effect of using History of Biology in the scientific literacy of students. This study gives the syllabus of reproduction and attaches importance to the history of biology. Opportunities for teachers to reflect on the possible uses of the History of Biology and to apply it in their teaching practice were considered necessary. The results proved satisfactory, confirming the advantage of using the History of Science in education.

Key words: History of Science, Science Teaching, scientific literacy.

INTRODUCTION

The advancement of science, technological, economic, social and political changes driven by globalization led the current society to a new course with undefined consequences. The designation of the information and knowledge society was generalized with the requirements that characterize it; the school is no longer the only way of learning and it exposes the unpreparedness of secondary school students to meet the challenges and requirements of the university education and the consequence of employing them in the labor market (Vasconcelos and Almeida, 2012). This is due to the contents and methodologies used in the European curricula, which give a little motivation to young people and discourage them to study science courses. Moreover, the authors report that there is a negative correlation between students' interest in the sciences (currently low) and their (often high) science test scores (Osborne and Dillan, 2008).

For these reasons, Science Education needs essential teaching and learning methodologies to easily transfer knowledge to students, for them to apply it in everyday life or professional situations and to assess the

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knowledge and skills necessary for scientific literacy.

The reading of specialized literature reinforces the imperative of the science teacher to know and to apply the methodology of education oriented to the History of Sciences, demonstrating its success in several levels of education in different countries. However, the History of Science can contribute to the collective enterprise an important means for human social activities and reduce the established prejudice that only sciences make a genius. In this context, it is essential that the teacher emphasizes the provisional character of laws and scientific theories, as well the role of the scientific community in its validation (Campos, 2012).

The History of Science is a motivating and instrumental knowledge because it can be an important tool for the science student and may be a future possibility to an increasingly competitive society.

This study was carried out considering the History of Science on the educational practice. Thus, the present study was developed according to the following objectives: to present the importance of the use of the History of Science in the teaching of Biology and Geology curriculum and to evaluate the impact of the use of the History of Sciences in Science teaching as a tool of scientific instruction.

Some considerations about the History of Science in Science Teaching

The history of science presents multiple dimensions, a vast variety of studies areas and research that have been built over the years, its theoretical bases and specificities. On the other hand, it constitutes a knowledge area with a strong and profound implications for Science Didactics, thus we can speak of History of Sciences in Science Teaching (Martins, 2007).

Over the last few years, the research in Science Teaching has evidenced the relevance of the role of History of Science in science teaching and learning (Martins 2007) (Silva and Rodrigues 2012). The History of Sciences can be thought as content (in itself) of the scientific disciplines and as a didactic strategy in the understanding of concepts, models and theories (Martins 2006). The inclusion of the History of Science in scientific curriculum can help students to have a vision of what is to build and do science, as well to understand that what is in the books today must be changed in five years' time (Rodrigues, 2007). The same authors said that the History of Sciences teaches us that nature changes as we continue to question and imagine. This movement will have implications in the conceptualization of science curricula and in the teaching practices about what to teach and how to teach (Duarte, 2003). The need for a historical approach to the contents of scientific disciplines also emerges from other perspectives, namely that represented by the CTSA methodology (Science-Technology-Society-Environment) for Science Teaching. In this line, the educational reforms indicate the necessity of historical-social contextualization of scientific knowledge (Santos, 2001).

Thus, there has been a rapprochement of the History of Sciences in the curriculum of science subjects in Portugal. The "students must learn the content of the present sciences and something about the Nature of Science" [10:34]. The inclusion of the History of Science in the teaching-learning process stimulates asking questions, creates new synergies and has a propelling effect in the advancement of Science Didactics.

In the 1970s, Portugal increased the interest in the contextual teaching of the sciences in Basic and Secondary Education, as well in university education (Prestes and Caldeira, 2009). This tendency led to the exploration of the historical, philosophical, social and cultural components of science to promote a formation that crossed the boundary between the teaching of scientific contents and their contexts of production. The new communities of researchers came from different specialized areas but with a common interest: the promotion of scientific education (Prestes and Caldeira, 2009).

New communities of science historians, philosophers of science and sociologists of science concerned with the problems of teaching and the learning in science have joined forces with researchers in teaching physics, biology and chemistry (already involved in the also emerging field of Science Education research). This sharing of views resulted in a significant increase in publications around the world which aim was to "*identify the contributions that different components of science have made to scientific education*" (Prestes and Caldeira, 2009).

In 1989, at the University of Florida, the First International Conference on History and Philosophy of Science and Science Teaching was performed, a great incentive for the establishment of the field of research that integrates professionals of the areas referred to above. Other conferences highlighted by the same authors aided a dialogue in the areas, especially with the appearance in 1992 of the Science and Education journal: *“Contributions from History, Philosophy and Sociology Science and Mathematics*” dedicated to the historical approaches, philosophical and sociological processes in the teaching and learning of science and mathematics (Prestes and Caldeira, 2009).

In the last decades the contextual perspective of Science Teaching has been incorporated in the official documents that integrate the curricular guidelines of several countries, such as the USA, England, France, Netherlands, Brazil, Denmark, Italy, Spain, Germany and Portugal.

Official United States of America (USA) and United

Kingdom (UK) documents are regularly present in the Brazilian literature in Science Teaching. On the other hand, UK teachers were invited to speak critically on the "Nature of Science" (NdC) through two documents from 1989 (Science in the National Curriculum and Science: non-statutory guidance), produced by “Department of Education and Science and the National Curriculum Council (NCC)”, respectively (Prestes and Caldeira, 2009). In the USA, contextual teaching of science was configurated in 1996 document by the *National Research Council (NRC)*, called the *National Science Education Standards*.

This new document of curricular guidelines followed the same parameters previously established by the *American Association for the Advancement of Science (AAAS)* translated into two publications: *Science for all Americans* (1990) and *Benchmarks for science literacy: Project 2061 report* (1993). In these curricular orientations understanding the nature of science was essential in science studies and consequently for scientific literacy; and the History of Science would be the most adequate tool to reach these objectives in the classroom (Prestes and Caldeira, 2009).

In 1855 the British Association for the Advancement of Science (BAAS) said that in teaching young people it is not only the results of scientific research that matter but also methods and above all the History of Science to promote science among them (Jenkins, 1992). The same British Association in 1918 made a new appeal for the use of the History of Science in classrooms and the use of scientific biographies to highlight the human aspects of science (Prestes and Caldeira, 2009). Moreover, in the same year the British Government presented a report, *Natural science in education* with the same objective previously mentioned but emphasized that the history and philosophy of science should be part of the intellectual knowledge of all secondary school teachers (Mathews, 1994).

These orientations were very important in the context from which they emerged; however in a society in line with World War I, the human dimension of science was based on highlighting the scientific discoveries that promoted the welfare of the society and the great scientists who inspired young people (Prestes and Caldeira, 2009).

This traditional approach of the History of Science can still be identified today in classrooms, despite the vast literature which contests it. In addition, this type of science teaching claims that it generates a distorted and mythological view of science and scientists (Martins, 2006; Rodrigues et al., 2016). In the 1950s, the British Society for the History of Science (founded in 1946) approached science teacher organizations, promoting the development of the curriculum and integrated activities between these two areas (Martins, 2006). However, other research mentioned that the courses and examinations derived from the earliest curriculum guidelines in the UK, the historical, social and cultural dimensions of science were ignored. In this way, the History of Science continued to play a minor role in the scientific curriculum of British schools during most of the twentieth century (Jenkins, 1992).

On the contrary, the academic production from the 50s increases in its publications in several countries. In fact, the decades of the 1950s and 1960s are characterized as proposals directed to curriculum planning, while in the 1970s and 1980s, there is an increasing interest for research on how to apply History and Philosophy of Science in the education of scientific subjects (Duschl, 1994). The perspective of Duschl and Mathews is emphasized by Prestes and Caldeira, who synthesize the general character of the treatment of scientific curriculum after the 1950s (Mathews, 1994; Duschl, 1994):

We consider fertile the approximation between the results found in the Duschl analysis and the perspective signaled by Michael Mathews that identifying two tendencies in the proposals of inclusion the History of Science in the scientific curriculum in the same period. One of them, the most recent, was called the "add-on approach". It is the introduction of specific historical episodes (or "case studies" of History of Science) into contents of a non-historical science course. This perspective has expanded partly due to the difficulties encountered by the previous approach characteristics of the 1950s and 1960s, which Mathews called an "integrated approach": the historical perspective served as the guiding line of all scientific content to be worked with the students in a given course program. In this case, each concept would be treated according to its origins and transformations as well as each method or practice would be analyzed according to its historical development (Mathews, 1994; Prestes and Caldeira, 2009).

This was the guiding principle of many works published between the 1950 and 1970s destined for secondary education and university education. These works became true successes and quickly spread as didactic references, especially in Physics (Prestes and Caldeira, 2009). The same authors consider that both, the integrated and the inclusive approach have their value in science teaching. However, they agree with other authors who assert that "the tendency to develop specific contributions will continue to be the majority" until "we can develop broader supports for large-scale projects (Allchin, 1992)." The inclusive approach provides the teacher with the freedom of "decision-making" in relation to the construction of the learning program, according to the educational models in force (Prestes and Caldeira, 2009).

Portugal had a past of scarce scientific culture in recent years, so it is important to reverse this situation through investing in education and scientific and technological diffusion; however there is still much to be done. Moreover, to promote the teaching of science in schools, it is necessary to increase our levels of scientific culture in other instances. For citizens to live better they need a minimum knowledge of the world and have an idea of how this knowledge is acquired (Fiolhais, 2011).

For many authors the teaching of sciences still translates into an overvaluation of the contents of science and on the contrary a devaluation or even omission about the History of Science and the nature of sciences (Cachapuz et al., 2001; Hygino et al., 2013; Gil-Pérez et al., 2001). There is weak impact at different levels of the teaching-learning process, when trying to promote the History of Science in the quality of teaching and learning of students and the main obstacle is the training of teachers (Duarte, 2003).

Recently, some studies carried out in Portugal still point to this trend; they highlighted that rarely science teachers use the History of Science in their classes because they did not have the opportunity to update themselves in this area. It is important to create opportunities for discussion about how science is developed and how scientific knowledge is developed (Gil-Pérez et al., 2001), contributing to reformulate the methodology that usually maintains the science teachers in many schools (Hygino et al., 2013).

This study used an inclusive approach for the History of Science (*add-on approach*) to obtain results about the use of History of Science in Biology classes. This type of approach seeks to introduce specific historical episodes into the contents of non-historical science course.

The inclusive approach has emerged and increased its diffusion due to the difficulties of the characteristic approach of the 1950s, called "integrated" (*integrated approach*), where the historical perspective served as the guiding line of all the scientific content to be worked with students in a given program of a course. For that reason each concept was treated according to its origins and transformations as well as each method or practice were analyzed according to its historical development (Mathews, 1994).

The general objective of this work was to investigate the impact of using History of Science in the learning of reproduction content, of the 11th year biology program (secondary school).

CONTEXT AND METHODOLOGY

This study was intended to identify the knowledge of the sample students about the reproduction of living beings. A qualitative methodology and descriptive statistics were used for data treatment.

In Portugal, the education is structured in 4 cycles: primary education or primary school that includes 4 years and children of 6 to 9 years; in the second cycle (with 2 years) the children are between 10 and 12 years old; in the third cycle (with 3 years) the children's ages are from 12 to 14 or 15 years and in the secondary school (with 3 years: 10, 11 and 12th) the young people are between 15 and 17 years.

This study involved 2 groups, group A (called Class A) where the research was developed and a control group (Class B).

To collect data, a quiz (pre-test) was done related to the History of Science at the beginning of the Reproduction content included in 11th year Biology and Geology program. At the end, the same quiz (post-test) was done with the study group (class A or 11°A) to determine their progress in this area. Moreover, to establish a relation, the same quiz was also done in another class of 11° B (class B) to make a comparison between the two classes and to verify the effect of History of Science on the students' scientific literacy.

Throughout the teaching of the reproduction content to class A, the History of Science was seen as very important by referring to some personalities related to this content, the difficulties inherent in the construction of scientific knowledge and the provisional character of the theories, principles or laws in science. Some resources and applied strategies that allow one to discuss this issue more satisfactorily were also elaborated. In Class B there was no reference made to the History of Science throughout the teaching of the same content. The 11° A class that was the object of this study (class A) consists of a total of 18 students (13 girls and 5 boys); their academic performance was average. The 11th class (class B) consists of 15 students (9 girls and 6 boys); their academic performance was considered good.

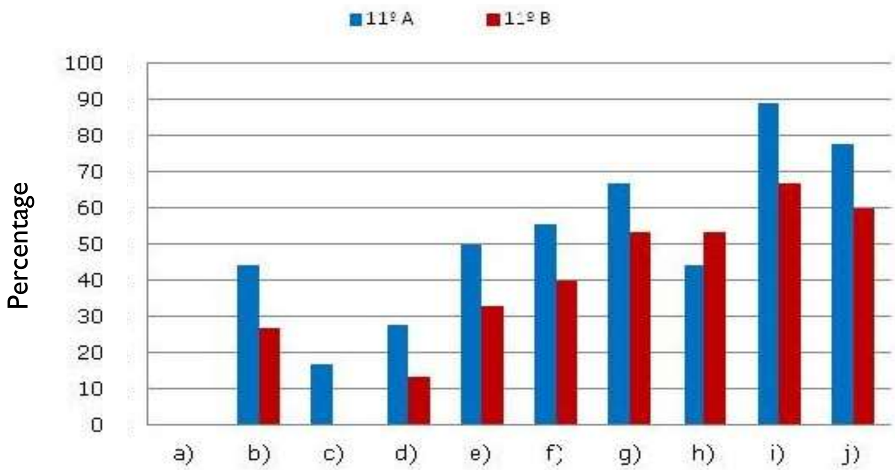
The pre-test applied (Annex 1) had the same questions with the post-test; therefore, it was necessary to find out if there was any evolution during the reproduction content teaching. The conditions in which the students performed the tests were the same: there were given about fifteen minutes to perform the test. The quiz only contemplates questions related to the thematic under study because we wanted to investigate if the use of HC contributed to the improvement of the understanding of the same.

During the teaching of reproduction, historical concept was introduced, from historical personalities involved in this thematic, as well the historical problems that they have arise in the resolution of scientific conflicts. Information resources and worksheets elaborated for this purpose were used as resources.

RESULTS

Here, the results of the pre-tests and post-tests of the two classes involved in the study were shown: the results of the pre-test was first presented in both classes, next was the post-test and then they were compared.

Figure 1 shows the results of the answers considered wrong. This set of statements was presented because they were the most worked on in terms of the evolution of their historical knowledge. Establishing a comparison between the two classes, 11B presented a lower percentage of wrong answers than 11A in all paragraphs except in point a, which any student of the two classes missed, and the letter h, where the percentage of students who made a mistake was higher in 11B. It was found that the highest percentage of wrong answers is found in section i, 88.90% obtained by students in class A and 66.70% in class B. This suggests that the students think that genetic variability and reproduction are



Content of ítems

a) Reproduction ensures the maintenance of life on Earth.

a) Asexual reproduction is based on mechanisms of fertilization and meiosis.
b) In reproduction the descendants are clones of the parent.
c) Asexual reproduction is ensured by the occurrence of mitosis.
d) In the budding there is the formation of protrusions, the buds that develop and separate, originating new beings.
e) In parthenogenesis, new individuals are formed without fertilization occurring.
f) In the multiple division there occurs division of a being into two with identical dimensions.
g) In sporulation, there is formation of reproductive cells, the spores, each of which can give rise to a new individual.
h) Genetic variability always occurs in reproduction.
i) Reproduction always involves the involvement of sex cells.

Figure 1. Comparison of percentages of wrong answers record by the pretest in classes A and B.

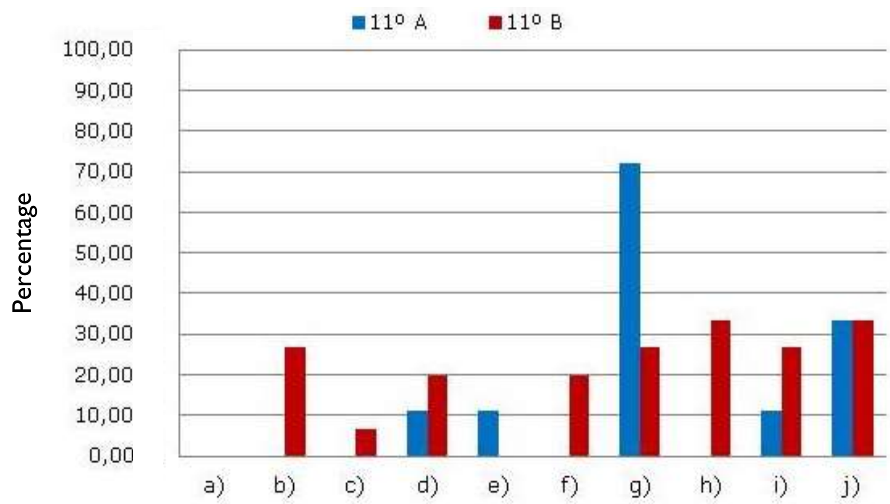
indissociable criteria; however, for example in asexual reproduction, unless mutations occur, the offsprings are genetically identical with the parents.

A large percentage of wrong answers were also found in item j, 77.80% of the class A students and 60% in class B, which explained that reproduction always involves the presence of sex cells (Figure 1).

Analyzing Figure 2 regarding the results of the post-tests, it was verified that all students of class A answered correctly a, b, c, f and h items, evidencing a clear evolution comparatively to the pre-test applied at the beginning of the reproduction content. For example, in letter f there was the most significant evolution, when more than half of the students did not answer correctly in the pre-test. The d, e, and i sections show the highest percentage of wrong answers, 11% in comparison to the pre-test; however, the students also evolved in these affirmations as they went against the correct answers. In section j, there was still a considerable percentage of wrong answers (33.30%), indicating that the learners still consider that sexual cells are necessary to reproduction. This can be due to the students' distraction, the difficulty to understand the content or the learning difficulties inherent in the class in question. However, the percentage was considerably lower than the pre-test. The g item was the only exception, since the percentage of wrong answers increased significantly from the pre-test to the post-test. These results can be associated with the scientific difficulty to understand this content, or by the students have made some confusion because in the multiple divisions new organisms are formed and not only two (Figure 2).

The students in class B also have a lower percentage of wrong answers in all items. The h and j items in the quiz presented an increase of the most doubts, since 33.30% of the students gave the wrong answers. On the other hand, in the same question of the post-test applied to the 11th A, five items were obtained with all the correct answers while in the post-test applied to the 11th B only two items were answered correctly in the totality of the students' class.

By making the relationship between the pre-test and



Content of items

a) Reproduction ensures the maintenance of life on Earth.
b) Asexual reproduction is based on mechanisms of fertilization and meiosis.
c) In reproduction the descendants are clones of the parent.
d) Asexual reproduction is ensured by the occurrence of mitosis.
e) In the budding there is the formation of protrusions, the buds that develop and separate, originating new beings.
f) In parthenogenesis, new individuals are formed without fertilization occurring.
g) In the multiple division there occurs division of a being into two with identical dimensions.
h) In sporulation, there is formation of reproductive cells, the spores, each of which can give rise to a new individual.
i) Genetic variability always occurs in reproduction.
j) Reproduction always involves the involvement of sex cells.

Figure 2. Comparison of percentages of wrong post-test responses recorded by classes A and B.

post-test, it can be concluded that the results obtained were very positive, since the students demonstrated a great evolution from one quiz to the other.

A similar study carried out with undergraduate students in Physics at UFRN, where quiz related to knowledge in History and Philosophy of Sciences was done, demonstrated scientific knowledge in this thematic (Martins, 2007). According to the author the students do not feel comfortable with this content although they are in favor of its use in teaching and recognize its importance.

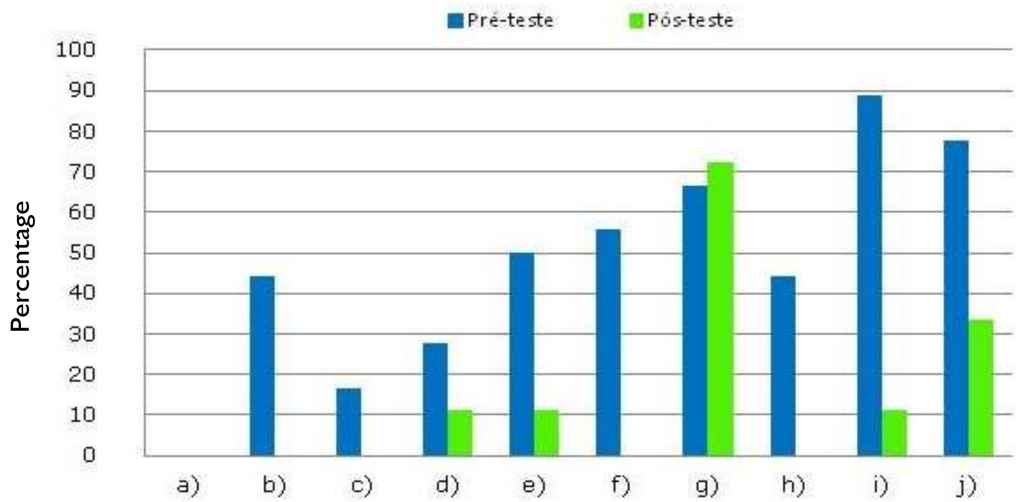
Comparing the pretest and posttest responses applied to class A, data showed a significant evolution on acquired relevant knowledge regarding the content of the reproduction by the students. Except for letter g of the quiz all the other items had a much lower percentage of wrong answers in the post-test (Figure 3).

Relatively, the pre-test and post-test applied in class B data showed that they also had positive results. The differences between the two classes under study is that 11th A presented a lower level at the beginning with the highest wrong answers percentage in the pre-test compared to the 11 B; however, in the post-test the erroneous answers' percentage of 11 B was higher than that recorded by 11 A class, indicating a greater evolution in the group where the reproduction content was developed according to the History of Science (Figure 4).

Generally, the present findings were positive showing the great evolution on the scientific knowledge about reproduction content by the 11th A class, although 11th B also presented good results and was already considered very good.

DISCUSSION

The present study demonstrates that the objective of the application of the History of Science in classroom was achieved. It was possible to verify that the History of



Content of items

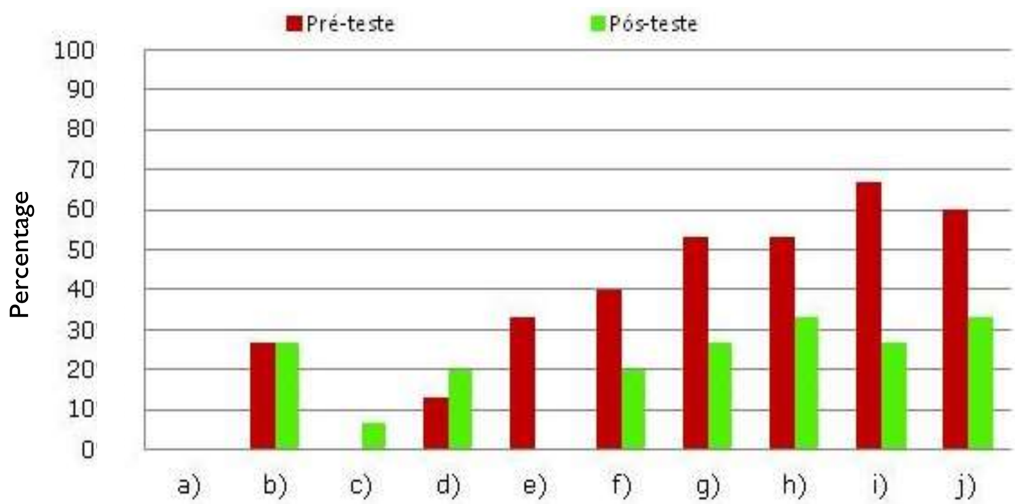
a) Reproduction ensures the maintenance of life on Earth.
b) Asexual reproduction is based on mechanisms of fertilization and meiosis.
c) In reproduction the descendants are clones of the parent.
d) Asexual reproduction is ensured by the occurrence of mitosis.
e) In the budding there is the formation of protrusions, the buds, that develop and separate, originating new beings.
f) In parthenogenesis, new individuals are formed without fertilization occurring.
g) In the multiple division there occurs division of a being into two with identical dimensions.
h) In sporulation, there is formation of reproductive cells, the spores, each of which can give rise to a new individual.
i) Genetic variability always occurs in reproduction.
j) Reproduction always involves the involvement of sex cells.

Figure 3. Comparison of the wrong answers percentages between the pretest and the posttest (class A).

Science had influenced the learning of the contents taught with positive results on the applied tests, enabling the researchers to make such assumptions. During the lecturing of the contents, a notorious interest was observed by students when introduced historical concepts, reason for why they believe that this approach brings students closer to the true reality of what it is to do and build science. A similar study was carried out by other research in Physics and they affirmed that "the production and application of the project emphasized that the insertion of the History of Science in the classroom is not something simple (...) requires general history knowledge by the teacher" and the authors concluded that the results were fruitful (Quintal and Guerra, 2009). Another study made by other author which referred to the teacher that applied History of Science in the classroom had the opportunity to increase the student's interest (Amador, 2010).

Conclusion

The importance of the History of Science in Science Teaching has been recognized in the last years within an extended number of studies. In the present study, attempt was made to achieve all the objectives considering that the commitment was ensured. Considering the investigation it is necessary to reinforce the importance of an adequate teaching of science in schools based on constructivism perspective, a methodology followed all over the pedagogical stage; the importance of the use of the History of Science in Science Teaching curriculum was also highlighted, demonstrating its potential through teaching by this methodology. In this work, the planning of the activities performed was presented, the theoretical description and the reflection of the pedagogical practices applied in the classes taught. Finally, the practical results of the



Content of items

a) Reproduction ensures the maintenance of life on Earth.
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i) Genetic variability always occurs in reproduction.
j) Reproduction always involves the involvement of sex cells.

Figure 4. Competition of the wrong answers percentages between the pretest and the posttest (class A).

implementation of the History of Science was presented while establishing a comparison between the class where the History of Science was applied and a group from the same school where the teacher did not use the History of Science.

Several authors mentioned throughout the this study reinforce that the History of Science must be an indispensable dimension in the education of young students. This importance has already been recognized by Physical and Natural Sciences curriculum. However, most of the teachers are not familiar with the History of Science and/or have a deficient formation in this area.

The present findings were very positive in the study group being in agreement with the literary revision about the importance of the History of Science. The students have shown a gradual evolution in the science area, contributing to improve their scientific literacy. On the contrary, in the group that participated in the study of this report where the awareness of the History of Science was lower than the study group, the improvement in the scientific literacy of these students was not significantly verified.

The lack of the History of Science implementation in Science Teaching shows the insufficiency of the measures taken and indicates the need to rethink teacher's education and training and one of the main shortcomings was evidenced in this study. For these reasons, it is essential to rethink the teachers' training institutions, universities and schools as true institutions of training and innovation. This change is not easy, and it is necessary to transform the way schools and their teaching is perceived; this transition can be hard, but it is not impossible.

Therefore, the diversity consecrated by the different histories and historical contexts brought by students can have an active intervention and make sciences more achievable and motivating for them, contributing to the development of a deeper interest in sciences. In fact, in the last decades there have been important initiatives in the approach of the History of Science and Science Teaching allowing the progress of scientific literacy.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Annex 1

Biology and Geology – 11° ANO	**2011/2012**

Quiz

This quiz is anonymous and is intended for the collection of data for a study.
Genre: Male___ Female___

1 – Explain in your own words the concept of reproduction.
____
____

2 – Indicate the reproduction forms you know.
____
____

3 – Mark as true (V) or false (F) the following statements:

a) Reproduction ensures the maintenance of life on Earth.
b) Asexual reproduction is based on mechanisms of fertilization and meiosis.
c) In reproduction the descendants are clones of the parent.
d) Asexual reproduction is ensured by the occurrence of mitosis.
e) In the budding there is the formation of protrusions, the buds, that develop and separate, originating new beings.
f) In parthenogenesis, new individuals are formed without fertilization occurring.
g) In the multiple division there occurs division of a being into two with identical dimensions.
h) In sporulation, there is formation of reproductive cells, the spores, each of which can give rise to a new individual.
i) Genetic variability always occurs in reproduction.
j) Reproduction always involves the involvement of sex cells.

4 – Explain in your own words the concept of fertilization.

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