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A Journey Inside Atomic Nucleous: Teaching-Learning Sequence Approaching Radioactivity

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Abstract

In September 13th, 1987, took place in Goiânia, capital of Brazilian state of Goiás, an accident with Caesium-137. In this context, it was the largest radiological incident, except considering the ones at nuclear power plants, according CNEN, the National Nuclear Energy Commission. Negligence in the storage of equipment in the ruins of the Instituto Goiano de Radioterapia (IGR), a private radiotherapy institute, was responsible for contamination of hundreds of people. With the opening of teletherapy radiation capsule, the environment was exposed to 93 g of highly radioactive caesium chloride, producing about six thousand Tons of radioactive waste, which were packaged in concrete containers and taken to the definitive repository located in the town of Abadia de Goiás, 23 km away from Goiânia, where CNEN installed the Regional Center of Nuclear Sciences to monitor radioactive waste and to perform environment control. Even almost three decades past the tragedy, the accident still leaves remnants of fear, mainly because there is a lack of knowledge of what really happened. The purpose of this work was to elaborate, apply and analyze a Teaching-Learning Sequence on Nuclear Physics, especially addressing radioactivity, totaling eight classroom meetings, aimed at undergraduate students in Chemistry and Brazilian public high school teachers from Itumbiara, a town located only 200 km away from the scene of this tragic accident. Our approach privileged the use of the History of Science, articulated to the conception of science as something that is not immutable, namely, that has continuous development. Initially, a test is applied to check participants' misconceptions. The students watched documentaries related to the Goiânia accident, and about concepts and phenomena in Nuclear Physics, followed by a discussion mediated by the teacher. Reading of texts and studies on radioactive decay and half-life, discussions on natural and artificial radioactivity were also implemented. Several test in punctual moments allowed to verify and feedback topics understanding. The results from the activities carried out highlighted that students' knowledge about modern physics is very limited, restricting considerably their world interpretation, revealing the need to insert such themes in basic education curricula.

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1. Introduction

In the global context, the accident with Cesium-137 was second only to the accident at the Chernobyl nuclear plant in Ukraine in 1986, according to the National Nuclear Energy Commission (CNEN, Brazil). The improper handling of an abandoned radiotherapy device at the facilities where the Goiano Institute of Radiotherapy operated was responsible for an accident that directly and indirectly involved hundreds of people. The opening of the capsule exposed to the environment 19.26g of Cesium-137, which generated 6000 tons of radioactive waste, packed in concrete containers and taken to the definitive repository in the city of Abadia de Goiás, 23 km from Goiânia, where CNEN installed the Center for Nuclear Sciences of the Center-West, which performs the monitoring of radioactive waste and environmental control. Even after three decades of the tragedy, the accident still leaves remnants of fear, mainly because there is a lack of knowledge of what actually happened. It is worth mentioning that the city of Itumbiara, Goiás, is only 200 km away from the site of this serious accident.

The focus of this work on radioactivity, based on the theoretical assumptions of Teaching Learning Sequences (TLS) [1], was chosen because of its importance for discussions in both Chemistry and Physics, as well as biological effects, and social context of the region. These aspects, according to Pietrocola (2008), are essential to identify school knowledge that has a greater chance of surviving and become a teachable learning in the classroom.

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2. Theoretical assumptions

Teaching Learning Sequences (TLS) as it is called in the international literature of science teaching [1] is based on the idea of "...a research involving the design, development and application of teaching sequences on specific topics, usually not lasting more than a few weeks" [2]. Such teaching sequences should emphasize the motivational and metacognitive dimensions of learning, providing the student with a basis for a better understanding of scientific content, since its elaboration considers the global, regional and local context.
The TLS is considered a differentiated didactic construction, whose choice of scientific contents to be approached involves theoretical justifications, with a problematizing perspective in relation to the context in which the target public is inserted, motivating students to seek knowledge that allows them to translate everyday events in an easy-to-understand language for them. This type of approach develops a close link between teaching and learning a topic, for example.
According to LIJNSE and KLAASSEN [1], one can divide the structure of the TLS into six phases and in the first phase, a didactic sequence should recall a global interest, and the reason for a study of the chosen subject. The second phase should, in turn, adjust the overall motive for the student's need for specific content knowledge. The third stage is to expand students' existing knowledge, considering the motivation and the need for more in-depth knowledge. In the fourth phase, this knowledge is applied in situations where it is needed. In the fifth phase, based on developed knowledge, the need for a theoretical orientation must be created. And finally, in phase six develop more theoretical knowledge within that orientation.
These phases can be developed through creative classes and activities, interdependent with each other, thus ensuring a coherence between content teaching and student learning, from different situations and formation of schemes to overcome conceptual difficulties faced by students. students. Allowing for a progressive and progressive advance of the students' level of knowledge until they have mastery of the conceptual field.
The principle of Vergnaud's work presupposes that knowledge is organized in conceptual fields, acquired by the subject over time, through experience, maturity and learning. Such conceptual fields constitute cutbacks of the physical world associated with cultural components, and Vergnaud defines them as an informal and heterogeneous set of problems, situations, concepts, relations, structures, contents and operations of thought, connected to each other and probably intertwined during the acquisition process [4].
For Vergnaud, conceptualization is the central problem of the process of knowledge acquisition. The author believes that the essential factor of students' difficulty in solving problems is not related to the separation between procedural knowledge and declarative knowledge, but closely linked to "operations of thought". For a given class of situations, the author considers that the situations are constituted by four elements: objective of the scheme, rules of action and control, operative invariants and possibilities of inference. Of these, only operative invariants are indispensable in the articulation between a situation faced by the subject and the scheme used by him to solve it.
When studying this process, care should be taken to maximize the student's ability to reason, since conceptualization is content specific and not logical or purely linguistic operations, or social reproduction or processing a information. This makes the theory of conceptual fields complex, since it requires the development of concepts and theorems of progressive and premeditated situations to be solved depending on the subject's cognitive level [4].
In short, what Vergnaud seeks to show is that a concept is not formed in just one type of situation, and a situation can not be explained from a single concept, a long process of construction and appropriation of concepts and situations is required for that there is learning.

3. Methods

A teaching sequence was elaborated with 12 classes, aiming at amplifying students 'already existing knowledge through varied activities to promote students' motivation and learning. Initially, the objective is to contextualize the content of Radioactivity by presenting students with a documentary about the radioactive accident of Goiania.
In order to verify the students' prior knowledge and their opinion on the subject, a questionnaire was elaborated with five questions for discussion in the classroom, with the purpose of showing students the need for more solid knowledge for the understanding of the theme, contemplating the second phase of TLS.
The next step was to propose an experimental activity for students to understand the transformations that may occur in the atomic nucleus, through a learning situation in which the student should present

an explanation for the phenomenon that occurs when there is an imbalance in relation to the amount of protons and neutrons in the nucleus of an atom (third phase).
Then, to continue the discussion about radioactivity, students should analyze the three families in which decay naturally occurs, using a puzzle-like game in which the pieces must fit together, organizing the elements as a series of radioactive decays. This activity serves as a systematization of the content discussed in the lesson, covering phases 4 and 5.
The next lesson was to present the historical context of the discovery of Radioactivity, and how technological advances started to be reflected in other fields, such as political, social, ecological and economic. reading and discussion of the text "Radioactivity and History of Present Time", published in “Revista Química Nova na Escola”, issue no. 19, in May 2004.
After reading and discussing the text, it was proposed to show the role played by physical and chemical knowledge in the development of technology and the complex relationship between Science and technology throughout history, through the exhibition of a series with six videos on topics of Radioactivity . Soon after watching the videos, the students will have about 20 minutes to relate them to the text of the previous class, using the following script (extracted from the didactic proposal of Giovana T. Pinto and Deividi M. Marques [5]):

1. What has changed in your concept regarding radioactivity?
2. Can one relate the luminosity of the hands of a clock to some of the phenomena described in the text?
3. What does radioactivity mean as an atomic phenomenon?
4. What do you mean by reading that one radioisotope is more active than another?
5. The Curie studies of the pitchblende - which is a uranium ore - istrusted the existence of another radioactive element in this. Because?

With these questions the teacher intends to create possibilities to explore the text and improve the concept of radioactivity. As students take over the knowledge, they want to apply it throughout their lives and in everyday situations, they aspire to the sixth stage, for developing more theoretical knowledge within that orientation. At that moment, it is possible to emphasize that the technology can improve the quality of life of the human being, as well as it can bring dangerous and harmful effects, everything depends on a responsible positioning.
In order to finish the sequence, the topic in focus was taken up with the students through a discussion guided by the question: Through all that was studied, radioactivity is young or villain ?, in which important aspects were debated about natural and artificial radioactivity . Most of the students responded according to the expectation that they would recognize that there is a good and a bad side and that everything depends on how and for what radioactivity will be used.

4. Discussion and Conclusions

The development of TLS can result in "good practices" within the classroom, and working with high school teachers and undergraduates based on their assumptions is quite valid, considering that how teachers learn influences their way of teaching. In Vergnaud's words to learn something new it is necessary to rely on previous knowledge, even if they may be obstacles to foreground. Thus, both TLS and Vergnaud's theory are complementary to each other, because to elaborate a good teaching sequence it is necessary to understand what interferes with the subject's learning and how this can occur.
During the 12 classes, students attended a documentary to situate them regarding the radioactive accident, followed by a teacher-led discussion, reading texts, such as "Radioactivity and the History of Present Time" to work out some of the students' the Science, watched videos on topics of Nuclear Physics, answered questionnaires that allowed to verify if they were understanding the content, as well as to show the students the need of more concrete knowledge to handle responsibly with certain situations, conducted studies on radioactive decay and time discussion of natural and artificial radioactivity. The activities carried out with the students allowed us to confirm that students' knowledge about modern physics topics is very limited, restricting too much the understanding of the world in which we live, ensuring the need to include such topics for the discussion of curricular contents. And despite the difficulties imposed to learn these subjects, with a good sequence of teaching it is possible for the students to learn truly, and to apply the acquired knowledge to other appropriate situation.

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