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Mathematics and Chemistry: An Interdisciplinary Experience in High School

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Abstract

This paper describes an interdisciplinary experience between mathematics and chemistry in a technical course of chemistry in High School at Instituto Federal do Rio de Janeiro. Our starting point was the lack of knowledge in basic mathematics presented by students in the first year of the course. These difficulties hinder students in both mathematics and chemistry classes. This situation motivated the development of our project, that constructed tools to explore exponential and logarithm functions in a chemical context. At the end of the project, we observed that the students were more interested in the mathematics and chemistry classes, besides presented a better performance in both disciplines.

1. Introduction

The teaching of natural science in Brazil started in the fifties and its goal was the training of scientific researchers. This fact contributed to foment the development of science and technology in the country. Only from the eighties that teachers of chemistry have had interest to promote connection between chemical daily knowledges and their chemistry classes [1].Nevertheless, the teaching of chemistry still is developed in a traditional form, without connection with the real world. Because of this, students do not have interest in the chemistry classes.Chemistry is an exact science and, for many students, it is a difficult subject. We may observe that many problems in the chemistry classes are related with a lack of knowledge in basic mathematics by students. On the other hand, mathematics is a required subject in the curriculum of technical of chemistry course at High School. As well as chemistry, mathematics is an exact science and also is considered difficult by students. Besides this, mathematics also is not interesting for students. Our starting point is this fact: how modify the mathematics classes, including chemistry problems, whose mathematics tools are necessaries for the development of chemistry themes? The term 'contextualization' appear in the brazilian curriculum parameters for High School [2] as an orientation for teachers in High School in the sense of propose, for students, real problems which may offer, for them, the opportunity to looking for the solution of these problems by their own methods. Based on this perspective, we proposed a contextualization for the mathematics themes that are used by chemistry. One of the alternatives for realizes the connection between mathematics and chemistry is mathematical modelling. The goal of mathematical modelling is to describe, to model, to formulate and to solve a real problem distinct of mathematics, involving procedures that conduct to the description and resolution of a mathematical problem, that traduce the original real problem [3]. This paper was divided at follows: in the section 2, we discuss the difficulties presented by students in mathematics and chemistry classes and the main motivation for the project. In the section 3 we describe the methodology used in the project and present the results and finally, the conclusion, in the section 4.

2. Why contextualize mathematics and chemistry?

The Instituto Federal do Rio de Janeiro, Campus Duque de Caxias has a technical of chemistry course at High School. The students enter in the institution only to study this technical course. They study in other schools until complete elementary school. Because of this situation, many students do not have the ideal notions of basic mathematics that are necessary for High School. Consequently, the technical of chemistry course has a high rate of failure by students in the first year of course. The technical of chemistry course is divided in seven semesters. Our project was developed in the second period of the technical course. We compare two groups of students: the first group, called group 1, had mathematics classes with traditional methodologies, without any contribution of mathematical modelling or chemistry problems and the second group, called group 2, had contextualized mathematics classes with mathematical modelling and chemistry problems during the semester. The group 1 had 25 students and the group 2 had 24 students.

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As we discussed in Section 1, the main focus of our project was improve the interest of the students fo r mathematics and chemistry, once this fact is pointed, by teachers of mathematics and chemistry, as an important element for failure of students in both subjects. Knowledge is the mind competence to ex press or form an information or event and uses it in an opportune moment. It reflects the intrinsic abili ty of cognitive system of remodel to produce new knowledges. All days we receive a lot of information that the mind discard or retain for a period of time. The learning process is related with the interest. It permeates any effort and comes before the learning [3].

3. The experience of mathematical modelling in a technical of chemistry course

In Brazil there is a minimum curriculum for the obligatory subjects for High School. In this sense, exponential and logarithms functions are included as obligatory themes for first year at High School in mathematics. The logarithms appeared in the XVII century as a tool for numerical calculus that are req uired astronomy and navigation. Nowadays, logarithms have applicability in several areas as financial problems, population growth or pH calculus, in chemistry [4]. As we described before, mathematical m odelling is an alternative teaching methodology. One of the strands for the mathematical modelling is t o try to awake the interest of the student and motivate him to learn through real problems. Learn, for u s, is to enable the student to use their knowledge in different contexts, that is, the student can solve pr oblems, make decisions with critical sense and creativity [3,7]. Our goal is to promote learning throug h mathematical modelling as described above. For Araújo [5], mathematical modelling cannot be treat ed only by mathematical aspect, but the students should integrate the process of modelling and the te achers should promote the critical thinking together to the process of modelling. As Schmidt and Di Fu ccia [6] described, "it is known that students have difficulties with connecting aspects of mathematics with chemistry, and teachers might be deterred from using mathematics in chemistry lessons due to th ose problems. However, considering the acquisition of problem solving skills in chemistry, it seems rea sonable to introduce tasks, which aim at problem solving by using mathematical models". Based on th is aspect, we propose a scheme in Figure 1 that describes the process of mathematical modeling appli ed in our project.

3.1 Mathematical modeling in a technical of chemistry course

Our analysis was constructed based on two ways: in a qualitative form and in a quantitative form. Firstly, we presented phenomenon related with exponential functions and chemistry. We proposed to the students that they solved the chemical problems with mathematical tools that they knew. During the process of resolution, we observed the mathematical difficulties related with power notion and, consequently, problems related with exponential functions.

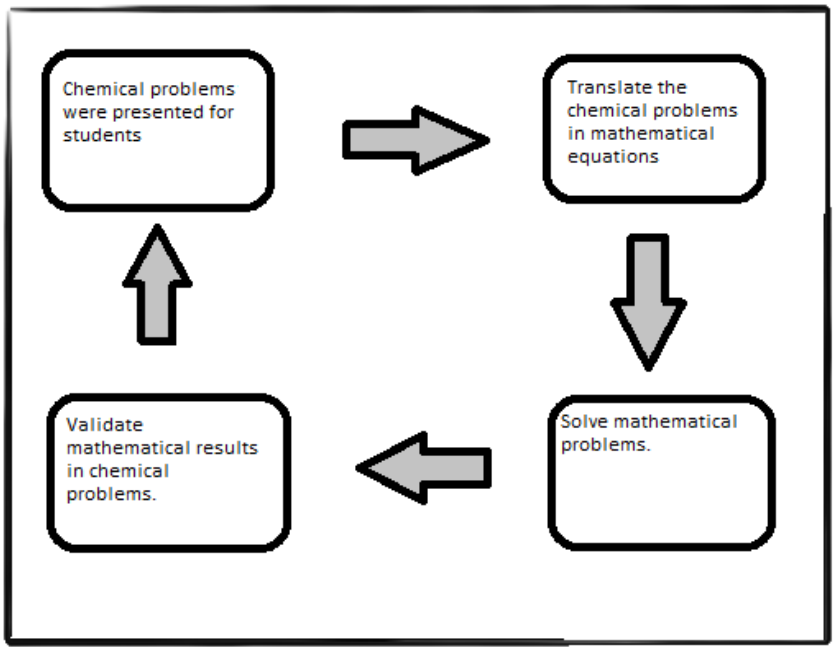

Figure 1: Schematic representation of each stage of our research.

In the next class, we introduced the notion of logarithms, a special case of exponential function. We presented the theme from the mathematical point of view in the first class with this theme. In the second class with this theme, we presented, as we made before, chemical problems but this time, chemical problems related with logarithms. The 24 students were divided in groups with three students and they solved some chemical questions. In order to illustrate our experience, we chose the problem that follows:

> As a consequence of industrial pollution, there has been in some places an increase of up to 1 000 times in the hydrogen ionic concentration of rainwater. Knowing that the normal pH of the water is 5.6, what would be the pH value in the case of acid rain mentioned above?
> Data: pH=2, Hydrogen concentration $[H_3O^+] = 10^{-2}$
> pH=3, Hydrogen concentration $[H_3O^+] = 10^{-3}$.

We observed that 83% of the students in the class solved the question correctly. Figure 2 represents a wrong resolution for this question presented by the students. We can note that the students were not to able to use the mathematical definition of logarithms correctly as well as they were to able to use also the properties of logarithms. We verified that students which answered correctly the question interpreted the chemical problem and used the mathematical tools in the right form.

3.2 Quantitative analysis for mathematical modelling

The process of uses mathematical modelling as a tool to contextualize mathematical themes with chemistry was repeated in five classes during a total of ten classes in the semester. We can observe the improvement of interest by students when they worked together in groups to solve the questions. As a consequence of this fact, we verified that the failure rate of these students (group 2) was smaller than the other group (group 1), which the teaching methodology was traditional without any relationship between mathematics and chemistry in the classes. The failure rate for the group 1 was 48% and the faillure rate for the group 2 was 16,7%.

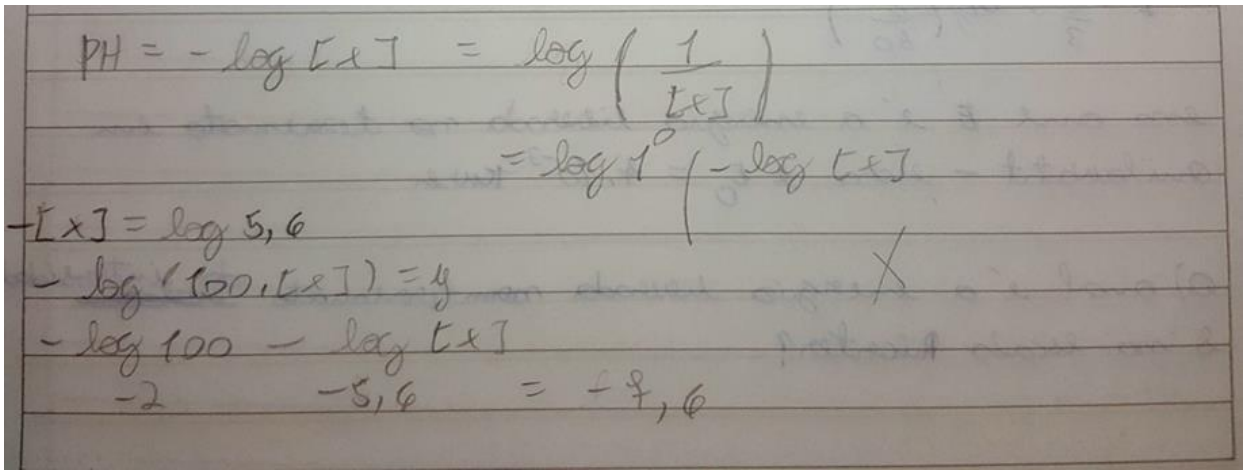

Figure 2: A wrong resolution presented by students for the chemical problem.

Our project was developed in a technical of chemistry course in High School, with students with ages between 14 and 18 years old. The major difficulty that we observe with the freshmen students in this course is the lack of knowledge in basic mathematics which should be acquired in primary school. As a consequence of this fact, we have a high rate of failure by these students. Other problem is the lack of interest by the classes due to the difficulties presented both in mathematics as in chemistry by these students. We compared the failure rate between two groups: group 1, with 25 students, which had mathematical classes with traditional teaching methods and group 2, with 24 students, which had contextualized mathematical classes through mathematical modelling. At the end of the project, we realize an analysis of the results under two points of view: quantitative aspects and qualitative aspects. As qualitative aspects, we highlight the improvement of interest of the students in the mathematical classes especially in the group discussions involving the contextualized questions. On the other hand, as quantitative aspects we highlight the failure rates obtained by the two groups: the

failure rate for group 1 was 48% and the failure rate for group 2 was 16,7%, that is, the failure rate was smaller with the alternative methodology of teaching. As future works we suggest a better connection between mathematics and chemistry, which the teachers of the two subjects work together during the semester. We believe that this integration may promote better results in the two subjects.

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