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Research Based on Design: Elaboration of Experimental Didactic Sequence

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Abstract

This research is guided by Design-based research, which combines aspects of educational research with practice in real environment. The goal was to create an experimental didactic sequence using low cost materials of easy access. The team was formed by a researcher in the field of chemistry teaching, a teacher of basic education and two students of licentiate in chemistry. The first step consisted in choosing the theme and design principles. The chosen topic was solutions and the design principles were problematizing experimental activities. The second step was the design, creation of the didactic sequence composed of three classes. During the design, it was considered the physical structure and financial conditions of the school. The materials used in the practical activities were low cost and easy to access and the activities were developed in the classroom because the school does not have a laboratory. The third step was the implementation of the didactic sequence for high school students of a public school in the State of Goiás, Brazil. In the first class, we exposed some products of daily use containing different types of mixtures and students should identify if the products were formed by homogeneous or heterogeneous mixture and argue their positioning. After the arguments, the teachers helped the students to identify the phases of a mixture, the differences between homogeneous and heterogeneous mixture using the materials that were exposed. In the second class, the students produced several acerola juices with different concentrations. During this experiment, the contents of solute, solvent, concentration and dilution were discussed. In the third class, an industrialized powdered acerola juice was made and students analyzed the juice label to identify which chemical additives are present and their functions. The results of this intervention corroborate with the researches in the area of science education that point out that the pedagogical potential and the capacity to arouse interest and curiosity in an experimental activity are in the capacity of the mediator to problematize the phenomena, to instigate the students, to explore the data, make relationships and contextualize the presented contents.

Keywords: *design, solutions, practical activities*

1. Introduction

Design-based research is a line that has emerged to develop a new interventionist methodology that seeks to combine theoretical aspects of educational research with practice. This line of research was introduced in the educational field by Brown (1992) [1] and Collins (1992) [2] from the concept of design experiments. This methodology has gained importance in educational research, from the growing academic production related [3],[4].

In research in science education, Design-based research has been used to plan, implement, and evaluate didactic sequences. According to Kneubi and Pietrocola (2017, p3) [5] “the DBR methodology manages the process as a whole, from the idea of innovation/creation to its effective implementation in a real environment”. The objective of this study was to create an experimental didactic sequence using materials of low cost and easy access and to evaluate its applicability in the classroom.

2. Methodology

This study is based on Design-based research, which combines aspects of educational research with practice in real environments [5]. The team was formed by a researcher in the field of chemistry teaching, a teacher of basic education and two students of the licentiate degree course in chemistry.

The first step consisted of choosing the theme and design principles. The chosen theme was solutions and the design principles were problematizing experimental activities, which are based on the valuation of the previous knowledge of the students and the contextualized teaching - and what is

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investigated arises from the problems present in the daily life - whose language should enable the construction of knowledge in chemistry [6]. The second step was the design, creation of the didactic sequence composed of three classes of 50 minutes each with the theme “acerola juice: concentrated or diluted?”. During the design, we considered the physical structure and financial conditions of the school. The materials used in the practical activities were of low cost and easy access and the activities were developed in the classroom. The third step was the implementation of the didactic sequence for high school students of a public school in the State of Goiás, Brazil. The fourth step was the evaluation of the entire production and implementation process in the classroom.

3. Results and Discussion

The purpose of this didactic sequence was to give high school students the opportunity to recognize day-to-day solutions and their solutes and solvents and to understand the dilution technique and how to calculate the concentration of a solution. The didactic sequence was applied together with the chemistry teacher of the school; 35 students of the second grade of high school participated.

3.1 First class

In class 01, an introduction was made on mixtures, solutions, types of mixture (homogeneous and heterogeneous), solute, solvent, number of phases and concentrations. During the presentation of the contents, the students were questioned if they recognize in their daily life some type of solution.

Some products of daily use such as soft drinks, non-carbonated water, sparkling water, acerola juices made from concentrated and diluted pulp, hydrated alcohol, copper + tin alloy, a balloon filled with atmospheric air, a piece of granite, one glass with water + sand, another glass with water + oil + sand. Students were asked to classify these materials into homogeneous or heterogeneous mixtures and justify their choices.

It was noticed that in the beginning, students presented a little difficulty during the classification of materials containing one or more phases, but the activity was very relaxed, had the participation of the students, and one student stressed the following: “*Understanding the explanations with experiments was very easy, the issues addressed when it comes to day-to-day life makes simpler the understanding*”. After the arguments, the teachers helped the students to identify the phases of a mixture, the differences between homogeneous and heterogeneous mixture using the materials that were exposed. The students were told that solutions are homogeneous systems, formed by mixing two or more substances. The solutions are composed of two components: the solute, which is the one that dissolves and is found in less amount, and the solvent, which is the component in greater amount and which acts to dissolve the solute.

3.2 Second class

In class 02, the concept of concentration was investigated. In this class, the students prepared the pulp from the fruit (Figure 1) and from that pulp they should prepare a concentrated juice and another diluted juice. In addition to the fruit pulp, it was also used artificial powdered juice (Figure 2). Students were asked to prepare three glasses of powdered juice, in the first glass, they should add 1 tablespoon of juice powder and 200 mL water; in the second glass, they added 4 tablespoons of juice powder and 200 mL water; in the third glass, they added 1 tablespoon of juice powder and 100 mL water. Through these data, the students described in which glasses the juices were most concentrated and in which ones, more diluted.

Figure 1: Acerola fruit

Figure 2: Artificial powdered juice of acerola

One student reported the following: "*It was very easy to understand the subject in a more relaxed and practical way, using the experiments, so we have a closer contact with the chemistry, I understood the subject better, it was a very good experience*".

3.3 Third class

In class 03, the critical reflection on the consumption of artificial juice was worked, initially the students identified the additives present in the label. Afterwards, the class was divided into three groups, each received a scientific text on food additives [7], [8], [9]. Each group did the reading and discussion of the text and then presented to the other groups what they understood about the topic. This activity provided a dialogue among the students and a reflection on the importance of preferring natural juices over artificial ones in the diet.

Through the reading and discussion of the texts, the students were able to identify the main chemical substances present in the powdered fruit juices marketed in Brazil and to verify which of these additives are responsible for the development of allergic or hypersensitive reactions in humans.

When working on the topic of chemical additives in foods using the juice that the students prepared, it was noticed that they became aware and asked many questions regarding chemical additives.

At the end of the proposed activities, students were asked to report on a sheet to be given what they could understand from the class and even the difficulties encountered in order to find out how efficient the methodology used was favorable for the teaching and learning process, and to later identify what could be improved in later classes. One student reported the following:

> "I really enjoyed the lesson, I found it easy to understand that industrialized chemicals such as powdered juice in excess can cause various diseases because of their compounds: dye, sweetener, flavoring, among others. I also had an easy understanding of the mixtures (homogeneous and heterogeneous) through the practical examples that the teacher brought to the room, from my daily life".

Another student made the following report regarding healthy eating:

> The use of artificial chemicals in food causes various damages to our body, because their composition contains several dangerous substances and are often used in excess causing health problems, so opting for natural foods is always the best choice, for the health and also for the environment".

The analysis of the process and on the implementation revealed that it is necessary to combine the chemical contents with the experimental part, which can be developed with materials of easy acquisition and that the students themselves can bring from home. Students lack experimental classes and it is necessary to create methodologies that combine theoretical chemical content with experimentation in an investigative and contextualized way and that allows a reflection on the implications of the use of chemical products in our daily life.

The results of this intervention corroborate with the researches in the area of science teaching that point out that the pedagogical potential and the capacity to arouse interest and curiosity in an experimental activity are in the ability of the mediator to problematize the phenomena [10], to instigate the students, explore the data, draw relationships and contextualize the presented content [6].

4. Conclusion

By implementing the teaching sequence in the classroom, in a real environment, it was possible to observe and interpret the process. It was from this context that the research data were extracted. This characteristic fills the practical-methodological dimension of science teaching and therefore attempted to bridge the gap between theory in education and the classroom.

Based on the elaboration and application of the didactic sequences, it can be noted that the participation of the teacher in the elaboration of the material is indispensable and of paramount importance, since the professional knows the audience to be served.

As for the application, it was noticed that the students feel more curious about the experiments, questioning and exposing their opinions, which collaborates a lot for understanding and relation of the topic and content of chemistry. The fact of working the content in a contextualized way allowed the students to understand the relationship that chemistry has with their daily life and how it can contribute to formulate an industrialized product.

It was noticed the need to work more experimental classes in the school, because these activities provided the students with a better understanding of chemical concepts, because they allied the

theoretical and practical dimension. Even the school did not have specific laboratory materials, it was possible to take practical classes with materials of the students' daily life. Thus, we suggest that to increase the frequency of experimental classes, teachers can use alternative materials, which can supply some substances or equipment that are absent in laboratories.

When analyzing the development of this didactic sequence, it is noticed that even though the concepts of common concentration were worked during class development, we still had to work on more exercises on common and molar concentration. For the next redesign, another class will be incorporated, which will include exercises on concentration.

References

[1] Brown, A. "Design experiments: theoretical and methodological challenges in creating complex interventions in classroom settings". The Journal of the Learning Science, 2(2), 1992,141-178.

[2] Collins, A. "Toward a design science of education". In Scanlon, E., & O'Shea, T. (Orgs.). New directions in educational technology. Berlin: Springer-Verlag. 1992.

[3] Van Den Akker, J. "Principles and methods of development research". In Van den Akker, J. et al. (Org.) The Design methodology and developmental research in education and training. The Netherlands: Kluwer Academic Publishers. 1999, pp.1-14.

[4] Mèheut, M., & Psillos, D. "Teaching-learning sequences: Aims and tools for science education research". International Journal of Science Education, 26(5), 2004, 515-535.

[5] Kneubil, F. B. Pietrocola M. "A Pesquisa Baseada em Design: Visão Geral e Contribuições para o Ensino de Ciências". Investigações em Ensino de Ciências, V.22 (2), 2017. p. 01-16.

[6] Francisco Jr., W.E., Ferreira, L.H., Hartwig, D.R., "Experimentação Problematizadora: Fundamentos Teóricos e Práticos para a Aplicação em Salas de Aula de Ciências", Revista Química Nova na Escola, n. 30, 2008. p. 34-41.

[7] Campos, T.; Batista, E.; Oliveira, K. N. "Aditivos alimentares: aplicações e toxicologia". Revista Verde Mossoró – RN - BRASIL, v. 8, n. 5, 2013. p. 01 – 11.

[8] Conte, F. A. "Efeitos do consumo de aditivos químicos alimentares na saúde humana". Revista espaço acadêmico n. 181 julho. 2016. p.1-13.

[9] Bissacotti, A. P.; Angust, C. A,; Saccol, A. L. "Implicações dos aditivos químicos na saúde do consumidor". Disciplinarum Scientia. Série: Ciências da Saúde, Santa Maria, v. 16, n. 1, 2015. p. 43-59.

[10] Delizoicov D., Angotti J. A. Pernambuco, M. M. "Ensino de Ciências: Fundamentos e Métodos". Editora Cortez, 2011. 365 pp.