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Articulation between problem solving and experimentation guided by problematized experimental activity (PEA): a proposal for chemistry teaching[2]

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ABSTRACT

It is accepted that the investigative dimension related to the field of Natural Sciences can be qualified through the use of strategies that permeate the proposition of problem situations, or Problem Solving, and that experimental activities show adherence to this theme, especially when related or originated by problematizations. Through this article, a didactic-pedagogical proposal is presented based on the association between the methodologies of Problem Solving and experimentation, interfaced by the Problematized Experimental Activity (PEA). Such research is of a Qualitative nature and, considering the organization of information and the production of new theoretical-methodological emergences, it also encompasses elements of Bibliographic Research. It is considered that the assertion developed is capable of generating autonomy and criticality to the students, providing, among other procedural-cognitive aspects, the construction of hypotheses, aiming at the (re)solution of the proposed problems, as well as the scientific argumentation based on these solutions and/or resolutions.

KEYWORDS: Science Teaching. Problematized Experimental Activity. Problem Solving.

INTRODUCTION

In the context of school education, specifically in the area of Natural Sciences, a genuinely qualified didactic strategy that can be used by the teacher is experimentation. Authors such as Ferreira, Hartwig and Oliveira (2010) mention that activities of this nature can favor the learning of scientific concepts and principles, as they offer broad conditions for theoretical, procedural and attitudinal appropriations.

Bearing in mind the official documents, the National Curriculum Parameters for Elementary Education (BRASIL, 1998) present a section dedicated to discussions limited to experimentation, while in the Curricular Parameters for High School (BRASIL, 2000) and in the Curriculum Guidelines for High School (BRASIL, 2006) mentions or discussions about this theme can be noticed, especially related to the discipline of Chemistry. In this, the development of experimental activities is configured as an important didactic stratagem in the context of Science Teaching, justifying deepening and consistent theoretical-methodological appropriations.

In this intention, Ferreira, Hartwig and Oliveira (2010) highlight the importance of experimentation presenting an investigative character, extrapolating a linear and rigid sequence of procedures, often standardized and reduced to manipulative techniques. A characteristic of investigative activities is their establishment based on problematization (LOPES; LEITE; HERMEL, 2021; BASSOLI, 2014). This perspective for experimental activities converges with didactic-pedagogical proposals presented in the National Common Curricular Base (NCCB), where it is verified, among other relative aspects, the intentionality of attributing an investigative character to the themes treated within the scope of the Natural Sciences area (BRASIL, 2017).

When approaching the area of Natural Sciences, references to research processes and practices are present in the NCCB. For Elementary Education, the NCCB presents that:

> [...] the investigative process must be understood as a central element in the formation of students, in a broader sense, and whose development must be linked to didactic situations planned throughout basic education, in order to enable students to reflectively revisit their knowledge and their understanding of the world they live in (BRASIL, 2017, p. 322).

Regarding High School, the NCCB (BRASIL, 2017) proposes that the investigative dimension of Science Teaching should be emphasized at this stage of school education, providing students with opportunities to approach investigation procedures and instruments, such as:

> [...] identify problems, formulate questions, identify relevant information or variables, propose and test hypotheses, elaborate arguments and explanations, choose and use measurement instruments, plan and carry out experimental activities and field research, report, evaluate and communicate conclusions and develop intervention actions, based on the analysis of data and information on the themes of the area (BRASIL, 2017, p. 550).

Although an investigative intentionality in the area of Natural Sciences is observable in the investigation procedures and processes presented at the NCCB, Zompêro and Laburú (2010) cite that investigative activities do not have the same objective observed in the 1960s: the training of scientists. Thus, the same authors point out that the investigation has the objective of developing cognitive skills, as well as procedures for the production of hypotheses, data analysis and argumentation (ZOMPÊRO; LABURÚ, 2010). In this last aspect, Sasseron (2018) addresses that the investigative process for Elementary Education dealt with in the NCCB is related to the promotion of investigative situations, marked by four modalities of actions: definition of problems; survey, analysis and representation; communication and intervention. The author highlights, however, a greater emphasis on actions related to the survey, analysis and representation, which can provide a protagonism to students with greater adherence to the development of understandings about conceptual and/or procedural knowledge specific to science (SASSERON, 2018).

With a view to teaching by investigation, Bassoli (2014) argues that this perspective is based on problematization, on the elaboration of hypotheses and on the testing of these hypotheses, using research procedures or practical activities. According to the same author, investigative experimental activities are part of teaching by investigation. Thus, it is clear that such a perspective can be developed through the use of strategies that permeate the proposition of problem situations. Thus, the pertinence of planning and developing experimental activities in Science Teaching is verified, especially when related or triggered by problematizations.

From the above, questions about which strategies can contribute to the correlation between experimentation and proposition/Problem Solving may emerge. Based on this scope, this article presents a didactic-pedagogical proposal for Science Teaching, with a preponderance of theoretical arguments, potentially capable of articulating the methodologies of experimentation and Problem Solving, guided by the premises of the Problematized Experimental Activity (PEA).

EXPERIMENTATION IN SCIENCE TEACHING

Ratings and potentialities

The association of experimental activities to curricular components such as Chemistry, Physics and Biology can be considered commonplace, since, after all, these components are part of the Natural Sciences area and are, of course, empirical. Not only, the use of experimentation is considered of great importance in Science Teaching (GALIAZZI et al., 2001; ZANON; UHMANN, 2012), and may present potential in the sense of favoring the understanding of scientific concepts and principles (FERREIRA; HARTWIG; OLIVEIRA, 2010). Despite such considerations of adherence and potentialities, Malheiro (2016) points out that experimental activities do not constitute a solution to all problems of Science Teaching, not without a deep understanding of various adjacent aspects, of a theoretical, methodological, pedagogical and epistemological nature, among others (GALIAZZI et al., 2001).

Many of the current criticisms that deal with experimentation are related to carrying out activities in which actions are centered on a rigid script to be followed by students (FERREIRA; HARTWIG; OLIVEIRA, 2010), where there is no stimulus for investigations into experiential aspects or the relationship between data/information, ideas and explanations (ZANON; UHMANN, 2012). In this sense, the Curriculum Guidelines for High School point out that experimental activities must extrapolate the character linked only to procedures and manipulations, promoting moments of study and discussion, which help in a theoretical/conceptual understanding through the teacher's mediation (BRASIL, 2006).

There are several factors that can guide the organization (planning and mediation) of experimental activities, such as objectives, availability of reagents, safety factors and students' familiarity with laboratory procedures. This diversity and plurality of elements may imply different formats for planning and conducting activities of this nature, under a pedagogical scope. Bassoli (2014), based on the work of Campos and Nigro (1999), lists experimental activities in four categories[1]: practical demonstrations, illustrative experiments, descriptive experiments and investigative experiments.

In *practical demonstrations*, the activity is carried out exclusively by the teacher, with the student restricted to observation. Bassoli (2014) points out that its use may be related to saving time or materials, as well as the initial introduction of lectures. In this type of activity, it is possible for students to have contact with phenomena, equipment and/or instruments, but depending on questions asked by the teacher to provide greater intellectual engagement to students. (BASSOLI, 2014).

Practical activities of this nature are also mentioned in the National Curriculum Parameters, adding factors pertinent to the development of this type of activity, such as the age group of the students and the use of materials and reagents that may pose a risk, such as acids, formaldehyde or fire. (BRASIL, 1998).

Illustrative experiments consist of activities carried out by the students themselves, but serving prior purposes and dependent on questions from the teacher, similarly to what happens in practical demonstrations. However, it should be noted that illustrative experiments have greater potential for social interactivity among students, when organized into work groups (BASSOLI, 2014).

Descriptive experiments are, analogously, activities carried out by students, providing the opportunity for the teacher not to conduct them in all stages of the process. In this type of experiment, students are encouraged to describe the observed phenomena and to produce their own conclusions about them (BASSOLI, 2014).

Finally, investigative experiments are those that provide an active participation of the student, as they necessarily involve the discussion of ideas and formulation of hypotheses, which are analyzed in between the experiment. Another outstanding characteristic of this type of activity is the use of questioning as the initial factor of the investigation, an idea that is central to the discussions that structure this article (BASSOLI, 2014).

Although considering the potential that investigative experiments present in the process of learning conceptual content, building relationships that allow the production of hypotheses and itineraries capable of leading to a possible solution to the problems presented, the importance of less autonomous activities should not be minimized as qualifiers to a learning process. Thus, the role of the teacher in the development and mediation of experimental activities is necessary, keeping in mind the search to enhance discussions, questions and inquiries, even in activities that focus on less effective participation of students..

Based on these assumptions, it is considered that the articulation of a didactic-pedagogical process of an experimental nature, within the scope of Science Teaching, in view of the development of favorable conditions for its learning, the given problem-situation, in its theoretical and methodological axis, consists of a potentially qualifying strategy. These assumptions will be treated.

Approaches from experimentation to proposition/Problem Solving

According to Silva and Moura (2018), experimental activities can present relevant characteristics of qualification to the teaching and learning processes, promoting to students the stimulus to the interpretation of information and the relationship of scientific knowledge to everyday aspects, to them familiar, and with that the awakening investigative curiosity to new questions and reflections. Such characteristics can be enhanced when students are offered the conditions to develop their own investigation methods (SILVA; MOURA; DEL PINO, 2018). The same authors suggest that an experimental methodology capable of promoting investigations and students' critical sense can be initiated by a concrete research question, a problem to be solved, from an experimental route still in the process of being defined (SILVA; MOURA, 2018).

With regard to investigative experimental activities, according to Suart and Marcondes (2009), these can contribute to the development of cognitive skills when planned and mediated in order to privilege student participation. It is also noteworthy that such experiments are developed from an initial questioning (BASSOLI, 2014). Corroborating the above, Goi and Santos (2009, p. 204) argue that "[...] experimentation in the school laboratory can promote opportunities for students to construct meanings through problem solving".

A possible approximation between the methodologies of experimentation and proposition/Problem Solving can also be perceived in the NCCB. In the section limited to High School, this document presents, among other aspects, about the investigative approach:

> At this stage of schooling, it must be triggered from open and contextualized challenges and problems, to stimulate curiosity and creativity in the elaboration of procedures and in the search for solutions of a theoretical and/or experimental nature (BRASIL, 2017, p. 551).

From the above, it is clear that a contributory aspect to the qualification of experimental activities, considering the teaching-learning relationship as procedural, can be its link to the proposition of initial problems. This aspect is linked to the assumptions of investigative activities. Considering the relevance of the problem in this perspective of argument, it becomes necessary to discuss what can be considered as a problem, as well as an understanding about the classification of problems, according to the purposes of this article.

According to Echeverría and Pozo (1998), a problem is defined as a situation that is recognized as such and for which "[...] we do not have automatic procedures that allow us to solve it more or less immediately, without requiring, in some way, a process of reflection or decision-making about the sequence of steps to be followed" (p. 16). Corroborating this definition, Lopes (1994) mentions that, despite the complexity of the notion of problem, there is a consensus that problems consist of something that does not know the answer and does not even know if it exists, that they have different levels of difficulty and complexity and that can have different formats than the traditional pencil and paper way.

Corroborating this, Echeverría and Pozo (1998) differentiate exercise problems, precisely because the latter have immediate resolution mechanisms. Thus, the same situation can be configured as a problem for an individual, while not for another. This is justified because the subject knows the resolution mechanisms, thus constituting the activity of an exercise, or even because he does not develop cognitive interest in the problematic situation that is presented to him.

Exercises and problems also present differences regarding the objectives of their use in the context of school education. Lopes (1994) mentions that exercises can be used to operationalize concepts, train algorithms, techniques, laws or rules, as well as exemplify given situations and/or simulations. In contrast, using problems is linked to the optimization of reasoning strategies, appropriation of concepts and development of knowledge/procedural knowledge.

Focusing on didactic perspectives, school problems can be classified in different ways, according to their characteristics and objectives. Pozo and Crespo (1998), considering the way problems are worked in class and their assumptions in the Natural Sciences curriculum, present the following classification: qualitative problems, quantitative problems and small researches.

Pozo and Crespo (1998) mention that qualitative problems are characterized by having their solution obtained through theoretical reasoning, without the need for numerical calculations, and that do not require experimental manipulations. They are open problems related to the explanation of facts or analysis of everyday or scientific situations through personal knowledge and/or scientific concepts.

Quantitative problems are related to the manipulation of numerical data to obtain a solution. In them, the information provided is quantitative and the resolution is based on mathematical calculations, data comparison and/or use of formulas. However, the final solution for the problem may be non-numerical.

Small researches, according to Pozo and Crespo (1998), are problems that require practical work to be carried out in the school laboratory or in other environments for their resolution. This type of problem presents closer relations to scientific work in relation to the previous ones, because it allows the student to formulate hypotheses, develop work strategies and reflect on the data/information obtained. However, although presenting a relative approximation to scientific practice, the didactic use of small researches has particular objectives:

> What is intended with this type of task is not for the student to be a scientist or to use the scientific method in their activities, but to bring them closer to the methodology of scientific work through observation and the formulation of hypotheses. It is also intended that students acquire certain attitudes (questioning, reflection on what is observed, etc.) and learn some useful procedures (search strategies, systematization and data analysis, etc.), both for possible and future scientific work and for understanding and interacting with the world around them (POZO; CRESPO, 1998, p. 83).

Pozo and Crespo (1998) indicate that small researches involve learning concepts, skills and strategies, and may adopt characteristics of qualitative problems (connecting prior knowledge to phenomena to be studied) and quantitative problems (using quantitative calculations). In this sense, the authors mention that, although they present such a classification, problems, especially the more complex ones, can be concomitantly integrated into more than one of the categories presented.

Bearing in mind the understanding of the broad relational potential between the teaching methodologies of experimentation and Problem Solving, along the lines discussed here, we intended to use the Problematized Experimental Activity (PEA) as a didactic-pedagogical strategy for planning and (possible) intervention.

Problematized Experimental Activity (PEA): fundamentals and potentialities

The Problematized Experimental Activity (PEA) can be characterized as a didactic-pedagogical strategy that tries to relate the methodology of Problem Solving to that of experimentation. This possibility is especially linked to the characteristic of PEA in being structured "[...] from the demarcation of a problem of a theoretical nature, that is, as a practical activity that aims at the search for a solution to a given problem-situation" (SILVA; MOURA; NOGARA, 2020, p. 04). In this way, the proposition of a problem is perceived as a fundamental part of the strategy, leading to an experimental activity that aims at its solution, from a procedural perspective (SILVA; MOURA; DEL PINO, 2018).

In the context proposed by the PEA, the professor acts as an advisor, promoting questions and overvaluing questions, a function different from that of centralizing answers and certainties, often adopted in his practice (SILVA; MOURA, 2018). Thus, heterogeneous methods, results and conclusions can be verified and valued, and such an attitude must be accepted and encouraged by the teacher (SILVA; MOURA; NOGARA, 2020). In this regard, the PEA aims to provide students with autonomy and protagonism, as they make records, discuss results, raise hypotheses, evaluate possible explanations and discuss, among their peers and with the teacher, the objectives, justifications and steps of the experiment (SILVA; MOURA, 2018).

However, despite presenting characteristics of proposing an initial problem, guiding and problematizing functions assumed by the teacher, heterogeneity of conclusions and development of a context that aims to provide the autonomy and protagonism of the student, the PEA has its own specificities regarding its theoretical-methodological structure. Therefore, the PEA is developed in relation to a theoretical axis and a methodological axis, which are briefly described in Chart 1:

Chart 1 - PEA constituent axes

Axes	
THEORETICAL – the planning	METHODOLOGICAL - the execution
a. Problem proposition b. Experimental objective c. Methodological guidelines	i. Previous discussion ii. Organization/development iii. Return to the work group iv. Socialization v. Systematization

Source: Silva e Moura (2018, p. 103).

The theoretical axis, associated with PEA planning, is structured from the proposition of a problem. This problem triggers an experimental objective and its methodological guidelines. Thus, in the PEA, the articulation between experimental objective and methodological guidelines is proposed, from the establishment of a problem (SILVA; MOURA; NOGARA, 2020). These articulators of the PEA theoretical axis – problem proposition, experimental objective and methodological guidelines – are presented below with characteristics and their articulations (SILVA; MOURA, 2018).

According to Silva and Moura (2018), the *proposed problem*, which establishes the PEA, is characterized by the need to elaborate a solution or derivation in other problems, a fact that differentiates it from a question, which admits an answer, being it capable of being considered "right" or "wrong". The same authors point out that in this perspective processes, strategies, methods and techniques of systemic investigation are privileged dimensions for problems, as well as the multiplicity of solutions, while questions are specifically related to the intended results.

With regard to PEA, other characteristics regarding the proposition of the problem need to be considered, since:

> In the demarcation of PEA itself, this problem should encompass a theoretical nature, preferably contextualized, linked to content units of interest. For its solution, it encourages the search for a route of experimental actions adaptive to different realities, which will lead to data that, after being transformed – collected, systematized, analyzed, understood and communicated – may lead to a solution perspective, qualitative and/or quantitative (SILVA; MOURA; NOGARA, 2020, p. 09).

From the above, it can be seen that the problem may have a contextualized dimension, however, it maintains a close relationship with the conceptual contents of interest to appropriation by the students. Another characteristic to be highlighted is the urgency of carrying out the experimentation aiming at a solution, in a reflective and analytical process on the data/information. In this way, from the problem, the experimental objective is elaborated and organized (SILVA; MOURA, 2018; FIGUEREDO; JOSÉ, 2022).

The *experimental objective* consists of a general and comprehensive objective for the experimentation proposal, that is, what is expected to be obtained/resulted through the experiment to be carried out (SILVA; MOURA; DEL PINO, 2018; SILVA; MOURA, 2018). Therefore, the aim is the technique that refers to data/information, which are transformed into results after due analysis, providing subsidies for the solution of the proposed problem. From this objective, the methodological guidelines are derived (SILVA; MOURA; NOGARA, 2020).

The *methodological guidelines* are presented as guidelines for carrying out the practical activity, approaching a protocol for the actions resulting from the experimental objective. In this way, "[...] deriving, therefore, from the experimental objective and guiding the search for its product, the guidelines represent instructions capable of guiding the actions to be developed experimentally" (SILVA; MOURA; NOGARA, 2020, p 10-11). According to Silva and Moura (2018), such guidelines are a necessary step, as they provide support for the first actions and general actions. It should be noted that they differ from a rigid script to be followed, as they admit (and even recommend) rectifications and adaptations by students and/or professors during the course of actions (SILVA; MOURA, 2018).

The methodological axis of the PEA, associated with the development of the activity, is composed of five moments: previous discussion, organization/development, return to the work group, socialization and systematization, and constitutes the didactic sequence of the proposal. This organization approaches the foundations of the Three Pedagogical Moments – problematization, organization and systematization of knowledge – proposed by Delizoicov and Angotti (1992) and the Historical-Critical Pedagogy proposed by Saviani (2011) (SILVA; MOURA; NOGARA, 2020).

According to Silva, Moura and Nogara (2020), the *previous discussio*n consists of the introductory moment, with the objective of identifying the initial knowledge of the students about the themes to be addressed. Its accomplishment may involve theoretical discussions, dialogued exposition of aspects related to the techniques and their fundamentals proposed experimentally, using resources such as texts, printed materials, open questionnaires, among others. Another characteristic of this moment highlighted by the authors is the approach of disciplinary knowledge related to the experimental practice to be developed. Thus, it consists, under "[...] a comprehensive perspective, to investigate their initial knowledge about, and, from this investigation, to introduce theoretical scientific foundations capable of guiding the next steps of the process" (SILVA; MOURA; DEL PINO, 2018, p. 51).

The *organization/development* of the experimental activity consists of the execution of the experiment, in its methodological nature. At this point, the theoretical problem, its experimental objective and methodological guidelines are presented. Subsequently, there is the organization for experimental work, in which students are arranged in small groups of individuals, with discussions and hypotheses arising from the proposed problem and their prior knowledge. Finally, students carry out the experimental activity, based on their own interpretation of the PEA, recording information and observations (SILVA; MOURA, 2018; SILVA; MOURA; DEL PINO, 2018).

The *return to the work group* includes a moment in which the discussion of the results of the experiment is foreseen, internal to each group, in view of the information generated from the experimental activity and its data/information collected and/or produced (SILVA; MOURA; NOGARA, 2020). Thus, the students "[...] move on to the cognitive development that guides an understanding of the experimental results obtained, followed by the interpretation [...] and perspectives of solution to the proposed problem" (SILVA; MOURA, 2018, p. 110-111).

During the *socialization* stage, dialogue takes place between the different work groups, considering possible methodological distinctions that may lead to different results and conclusions. At this stage of the development of the PEA, the discussion about the procedures carried out in the experimentation, the conceptions of mistakes and successes of the students, as well as the theoretical elaborations capable of providing a solution to the problem that originated the PEA (SILVA; MOURA; DEL PINO, 2018).

Finally, according to Silva, Moura and Del Pino (2018), in the *systematization* stage, the generation of a product is possible, assuming that this production is an essential action for learning. The same authors point out that this activity unfolds with a certain individuality, presenting systematizations of the conclusions that provide a solution to the problem. It involves textual production by the students, addressing the knowledge produced through the experimental activity, the information produced and collected, the guiding questions, as well as aspects arising from theoretical research, in whole or in part (SILVA; MOURA; DEL PINO, 2018).

Still regarding the moment of systematization, Silva and Moura (2018) argue that it is a recurring fact in the school context to request the production of a report as a post-experimentation activity. In the context of PEA, this strategy can be maintained, however, when guidelines for its production are presented. To do so, providing subsidies to students for coherent writing, so that they can satisfactorily express results and observations, recognizing the constructive characteristic of scientific communication.

METHODOLOGICAL PROCEDURES

The theoretical-methodological articulation, materialized in this planning, carried out and reported in this article, is configured as qualitative, a methodology that, according to Lakatos and Marconi (2017) and Gil (2017), aims to obtain a particular understanding of the object to be under study. That said, it is still considered that qualitative research "[...] focuses its attention on the specific, on the peculiar, its interest is not to explain, but to understand the phenomena that it studies within the context in which they appear" (LAKATOS; MARCONI, 2017, p. 299).

The organization/systematization of data/information, considering the specificities of school education and the area of Natural Sciences, began with the definition of the theme, object of investigation, in this case, the methodology of experimentation. Subsequently, a theoretical study was carried out on the themes "experimentation in Science Teaching", "approaches between experimentation and proposition/Problem Solving" and "Problematized Experimental Activity (PEA)". This stage of theoretical study presented approximations with the foundations of Bibliographic Research, in which, after defining the research topic, a preliminary bibliographic survey is carried out which, when understood as an exploratory study, provides an approximation with the theme to be researched, allowing its delimitation and potentially facilitating the formulation of the research problem (GIL, 2017).

Furthermore, the theoretical and conjectural nature of the articulation adopted between the grounds of Problem Solving and experimentation is highlighted, the latter embodied by the Problematized Experimental Activity. In this respect, methodological propositions are derived from it, in view of broad perspectives of adherence to the praxis of Chemistry Teaching.

RESULTS AND DISCUSSIONS

Perspectives of articulation between the methodologies of experimentation and Problem Solving for didactic purposes can be perceived in several works and academic research. In this context, the article by Goi and Santos is cited, in which data from a qualitative research are presented about an experience of using experimental activities in Chemistry, based on the Problem Solving methodology (GOI; SANTOS, 2009). Martins' master's thesis, in which Problem-Based Learning was linked to Problematized Experimental Activity, using the context of sodium, supported by the Science-Technology-Society-Environment approach (MARTINS; 2020), can also be mentioned as similar to what is reported in this article.

As a proposal for articulation between experimentation and Problem Solving, the fundamentals and assumptions of the Problematized Experimental Activity (PEA) were considered pertinent. In this sense, didactic-pedagogical activities were planned, whose associative relationship is based on the PEA. These activities were organized in a didactic sequence, summarized in Chart 2.

Chart 2 - Summary of proposed activities

Class	Duration	Activities
01	1 hour-class	Presentation of the proposal, reading and discussion of texts on the subject
02	1 hour-class	Problem proposition (Problem 01)
03	1 hour-class	Discussion of problem resolution and proposition of a new problem (Problem 02)
04	2 hours-class	Discussion of problem solving and lecture on mixtures and mixture separation processes
05	2 hours-class	Experimental activity based on the PEA

Source: Own Authorship (2022).

As for the activity guided by assumptions of Problem Solving, the proposition of two problems was planned, which are presented in Chart 3:

Chart 3 – Proposed problems

Problems
1) Investigating water consumption Water is one of the essential substances for life on our planet. Despite the large amount of existing water, potable water, that is, the water available for human consumption, is much lower, as much of the water is salty. It is estimated that of every 1000 liters of water, only approximately 6 liters are potentially available for human use. Considering its use, agriculture consumes 69% of the available water, industry 23% and only 8% is intended for domestic consumption. However, increasing pollution and degradation of freshwater sources reduce the availability of this natural resource. (Source: REIS, M. *Química. volume 1*. São Paulo: Ática, 2013). Considering the above, one can see the importance of preservation and the conscious use of fresh water, which goes through a good domestic use of this natural resource. But do you know how many liters of water you use daily? To answer this question, develop estimation strategies capable of indicating the quantity in liters of water used individually in your home, organizing ways to calculate and display the individual consumption of each resident.
2) Researching water and sewage treatment Several public health risks may be related to some possible and undesirable factors that may occur in urban and rural areas, which can be minimized or eliminated with the appropriate use of sanitation services. The use of potable water is seen as providing this supply safely to the population, while the sewage system promotes the interruption of the chain of human contamination. These are some examples of the effects of sanitation actions on health: • Good quality water for human consumption and its continuous supply ensures the reduction and control of diarrhea, cholera, dengue, yellow fever, trachoma, hepatitis, conjunctivitis, poliomyelitis, scabies, leptospirosis, typhoid fever, schistosomiasis and malaria. • Adequate sanitation is a factor that contributes to the elimination of vectors of malaria, diarrhea, worms, schistosomiasis, cysticercosis and taeniasis. (Adapted from: Sanitation for Health Promotion. Available at: http://www.funasa.gov.br/saneamento-para-promocao-da-saude. Accessed on 03/07/2021)). 1) From the above, one can see the importance of providing treated water to promote improvements in the quality of human health. In general, how is water treated for human consumption? What are the stages of this treatment and how do they work (set up a representative diagram of the processes involved)? How is water treated in your municipality? 2) The occurrence of water pollution can cause damage to the environment and human health. Therefore, it is important to reduce this type of pollution. But what could be identified as the main forms of water pollution in your municipality? What possible impacts on the environment could they cause? How could these forms of pollution be minimized?

Source: Own Authorship (2022).

From Table 3, it can be seen that Problem 1 is related to the issue of water availability and consumption, while Problem 2 is linked to the treatment of water for domestic consumption and water pollution. In the first, quantitative aspects are predominant, while in the second, qualitative information predominates. However, both adhere to social aspects that are potentially familiar to students and, therefore, promote conditions for theoretical articulations with various formal contents and prior knowledge.

As discussed in the theoretical framework of this article, Pozo and Crespo (1998) classify problems as qualitative or quantitative (as well as small researches). These differ, as qualitative problems are solved by students through theoretical reasoning, based on their knowledge and without the use of numerical calculations, while in qualitative problems the solution is obtained through the manipulation of numerical data, and its resolution based on mathematical calculation, use of formulas and data confrontation (POZO; CRESPO, 1998). Thus, Problem 1 presents quantitative and qualitative characteristics, while Problem 2 approaches the qualitative characterizations.

The proposed experimental activity follows PEA premises, where in its theoretical axis the experiment is articulated from a problem, triggering the experimental objective and, from this last one, the methodological guidelines are derived. With reference to the proposed problem, there is:

> From the perspective of a PEA, the presented problem itself can awaken in the student motivation, interest, intellectual challenge and ability to discuss and articulate ideas, promoting the necessary self-confidence to seek to present explanations to the observed phenomena (SILVA; MOURA; DEL PINO, 2018, p. 178).

In this sense, Silva, Moura and Del Pino (2017) point out that PEA can awaken students' interest in scientific themes, since these are articulated from a theoretical problem whose solution occurs through the elaboration of a route of experimental investigation. And, considering an experimental teaching concept based on the search for solutions to problems, PEA can provide students with autonomy and protagonism, since they register, discuss results, raise hypotheses, evaluate possible explanations and discuss the reasons and steps of the experiment (SILVA; MOURA; DEL PINO, 2018). Thus, it is clear, in this organizational perspective for experimentation, that the proposed problem and the possibilities of derived actions to be carried out by students have potential relevance for their learning process.

Another aspect of interest regarding Problems 1 and 2 (Chart 3): in view of their relation to everyday aspects and, moreover, because they preserve intelligible elements of objects of knowledge in Chemistry, they are configured as favorable to the development of experimental activities in PEA templates. This justifies the practice reported in the sequel to this article, as one of several possibilities.

Considering the theoretical axis that constitutes the PEA, Chart 4 presents the planning of the experimental activity proposed here, which involves concepts of mixtures and processes of separation of mixtures.

Chart 4 - PEA Planning

Title: Separation of heterogeneous mixtures
1) Theoretical Foundation Mixtures are common in our daily lives, and may be formed by pure substances. A mixture is defined as “[...] a portion of matter that corresponds to the addition of two or more pure substances” (PERUZZO; CANTO, 2010, p. 30). Mixtures can have one or more phases. The word phase originates from the Greek *phasis*, which means appearance or visual aspect (REIS, 2013). One can define “[...] phase as a portion of a sample of matter that presents the same properties” (PERUZZO; CANTO, 2010, p. 31). Thus, if a mixture has constant appearance and properties throughout its extension, it has a single phase. However, if appearance and properties are different at points in the mixture, it has more than one phase (REIS, 2013). According to the number of phases, mixtures can be classified as homogeneous or heterogeneous. Mixtures are homogeneous when, to the naked eye, they present a single phase, presenting a single appearance at all points; mixtures are heterogeneous when they present two or more phases, presenting regions with different aspects (PERUZZO; CANTO, 2010; NOVAIS; ANTUNES, 2016). Homogeneous liquid/liquid and solid/liquid mixtures can be separated by fractional distillation or simple distillation, respectively. In these two processes, all components of the mixture can be recovered. Another process for separating homogeneous solid/liquid mixtures is evaporation, in this case, recovering only the solid component. (PERUZZO; CANTO, 2010; NOVAIS; ANTUNES, 2016). Heterogeneous mixtures can be separated by several processes. When solid/liquid or solid/gas, filtration can be used, in which the solid phase is retained by the filter. Decantation can be used to separate solid/liquid mixtures, in which the denser phase tends to occupy the lower part of the container. Decantation can also be used in a heterogeneous mixture composed only of liquids, in which the decantation funnel is used, allowing only the densest liquid to drain. Screening (or sieving) is a process used to separate solid/solid heterogeneous mixtures, due to the difference in the size of the solid grains, in which the sieve mesh only allows the passage of smaller grains (PERUZZO; CANTO, 2010; NOVAIS; ANTUNES, 2016; LISBOA et al, 2016). Mixture separation processes can be used in several activities. In petroleum refining, fractional distillation procedures are used; for the separation of atmospheric air components, such as oxygen and nitrogen, processes of air liquefaction and subsequent distillation are used; salt production in salt flats occurs through evaporation (PERUZZO; CANTO, 2010; REIS, 2013; NOVAIS; ANTUNES, 2016; LISBOA et al; 2016).
2) Materials Universal holder, funnel gripper, loop, glass funnel, filter paper, beaker, watch glass, glass rod, separating funnel, magnet, spatula, sieve, beaker, analytical balance.
3) Reagents Water, soybean oil, sand, gravel, iron filings.
4) Proposed Problem In an industry, in the process of maintaining its equipment, parts and machinery are washed. After the washing process, the water used has a large amount of waste sand, gravel, iron filings and oils, and to avoid polluting aquatic environments, it cannot be released directly into the environment. It is necessary to implement processes that allow the separation of these wastes from water. What are the procedures that could be used to remove these residues from the water, recovering them separately at the end of the process?
5) Experimental Purpose To produce heterogeneous mixtures and carry out processes of separation of mixtures, observing the recovery of its components.
6) Methodological Guidelines

Title: Separation of heterogeneous mixtures
1st part: producing heterogeneous mixtures • Place a certain volume of water in a beaker; • Introduce amounts of sand, gravel and iron filings into the water; • Separate a volume of soybean oil and introduce it into the mixture; • Record the number of phases observed in the mixture. 2nd part: separating heterogeneous mixtures • Choose a sequence of separation processes to recover all components of the produced mixture; • Build a scheme for separating the components of the mixture; • Perform the separation of the mixture with the chosen separation processes, noting procedures, observations and conclusions; • For the mixture separation procedure, the guidelines below are recommended: 1) Filtration (solid/liquid heterogeneous mixture) a) Fold the filter paper properly; b) Form a cone with filter paper and place it in the glass funnel; c) Wet the filter paper with water; d) Using a ring, attach the funnel to the universal support, positioning it above a beaker; e) Drain the mixture, using a glass rod, into the funnel. 2) Decantation (solid/liquid heterogeneous mixture) a) Place the mixture in a beaker; b) Wait for the solid phase to settle; c) Carefully tilt the beaker containing the mixture, draining the liquid phase into another beaker. 3) Decantation with a separatory funnel (heterogeneous liquid/liquid mixture) a) Using a ring, attach the decanting funnel to the universal support, positioning it above a beaker; b) Check if the decanting funnel has the tap closed; c) Place the mixture in the decanting funnel; d) Open the tap of the decanting funnel, draining the densest phase into the beaker; e) Close the tap at the end of the flow of the denser phase; f) Place the remaining phase in another beaker. 4) Screening (solid/solid heterogeneous mixture) a) Place the mixture in a sieve; b) Perform phase separation. 5) Magnetic separation (heterogeneous solid/solid mixture) a) Place the mixture spread over a watch glass; b) Bring the mixture into contact with a magnet; c) Place the iron filings in a beaker.
7) Proposed Questions 1. Was the sequence chosen for the separation of the mixture feasible? 2. How did the experiment lead to the resolution of the proposed problem? 3. Would it be possible to propose another sequence of separation processes for the mixtures produced? If yes, assemble a schematic sequence of the mixture separation processes involved. 4. Consider that at a given moment, the water used in the equipment washing process of the fictitious industry exemplified in the problem showed only sodium chloride residues. How would you proceed to separate this mixture? Explain the process used.
8) References LISBOA, J.C.F.; BRUNI, A.T.; NERY, R.M.L.; LIEGEL, M.R.; AOKI, V.L.M. *Ser Protagonista: Química*, *1º ano*. São Paulo, Edições SM, 2016

Title: Separation of heterogeneous mixtures
NOVAIS, V.L.D.; ANTUNES, M.T. Viva: *Química, volume 1*. Curitiba: Aprende Brasil, 2016. PERUZZO, F.M.; CANTO, E.L. *Química na abordagem do cotidiano, volume 1*. São Paulo: Moderna, 2010. REIS, M. *Química. volume 1*. São Paulo: Ática, 2013.

Source: Own Authorship (2022).

Regarding the proposed PEA, the problem presents relations with the environmental theme, more specifically, with water pollution. In this way, the objective was to bring it closer to the problems proposed in the previous activities, as well as to contextualize it through a relevant theme of discussions and reflections in the current context, but which presents potential for approaching the chemical concepts correlated to the experimental activity. As such, an attempt was made to approximate the proposed problem to that exposed by Silva, Moura and Nogara (2020, p. 09), in which "[...] in the demarcation of PEA itself, this problem should encompass a theoretical nature, preferably contextualized, linked to content units of interest".

In the experimental objective, it is suggested the production of heterogeneous mixtures and the realization of processes of separation of these mixtures. Thus, such experimental activities can produce results related to the resolution of the problem, however, without presenting a previously defined experimental script, seeking to be in line with Silva, Moura and Del Pino (2017, p. 183), where it is verified that the experimental objective "[...] is an experimental axis that will guide the main action to be developed, that is, a technique that will result in data capable of generating a solution".

The methodological guidelines were organized in order to subsidize the students for the production of a heterogeneous mixture whose components coincide with the residues present in the water (proposed problem), as well as the possible experimental itineraries for the separation of this mixture. It is noteworthy that the guidelines related to the processes of separation of mixtures allow the autonomy of the students, in the choice that they will be able to make of which procedures will be carried out; propositions guiding the procedures to be carried out, not imposing, that is, adaptable by students and professor (SILVA; MOURA, 2018).

In view of the approximations between experimentation and Problem Solving, along the lines addressed in this article, correlations were aimed at two different aspects: the first, contemplating the theme present in theoretical problems and in practical activity; the second, covering the triggering of the experiment from the proposition of a theoretical problem.

In the first relational aspect between Problem Solving and experimentation, the theme related to water was used as an element for the correlation between problems and experimentation in a didactic sequence format. Thus, this sequence was organized starting from the context of domestic water consumption, following the treatment of water and sewage in Problems 1 and 2, ending with the experiment of separation processes of mixtures with problems related to water pollution.

The second aspect was based on PEA as a didactic-pedagogical strategy. The articulation between experimentation and Problem Solving is linked to the PEA, as, among its specificities, it is structured from the proposition of a problem of a theoretical nature, and configures itself as a strategy to solve this problem-situation (SILVA; MOURA, 2018). The PEA presents the problem at its origin, that is, the practical activity is proposed from the demarcation of the problem (SILVA; MOURA, 2018). Thus, to face the problem, a possibility of solution is sought through the methodological use of experimentation (SILVA; MOURA; NOGARA, 2020), observing similar characteristics in problems classified as small researches, whose students obtain the solution through a practical work (POZO; CRESPO, 1998). However, the PEA has its own structure, theoretically organizing itself through the proposition of the problem, experimental objective and methodological guidelines and, methodologically, from the moments called prior discussion, organization/development, return to the work group, socialization and systematization (SILVA; MOURA; DEL PINO, 2018).

Based on the above, this section intends to present didactic-pedagogical proposals that potentially qualify Science Teaching, in the particularities of Chemistry, in the light of the theoretical framework adopted in this article. When dealing with frequent and forceful methodologies in the contexts of Science Teaching, in view of the teaching and learning processes of Science, its articulation is suggested based on the characterization of theoretical-methodological foundations capable of qualifying the teaching mediation, with strong commitment to learning development; such articulation is intended by the foundations of the Problematized Experimental Activity. Based on this, by way of example, 5 classes were proposed, limited to the referenced methodologies, based on the application of which arguments can be raised for analysis and the development of new plans, with potential interventions.

FINAL CONSIDERATIONS

The aim of this article is to present a proposal for a didactic intervention, with potential for mediation in the school environment, covering Problem Solving and experimentation activities. In this sense, we sought to develop theoretical-methodological articulations between these teaching-learning strategies, since the proposed problems present thematic relations with the experimental activity, as well as the methodological articulation between Problem Solving and experimentation is justified, here materialized through the Problematized Experimental Activity, in which the proposition of a theoretical problem promotes the development of the experimental procedure (SILVA; MOURA; DEL PINO, 2017).

With regard to the problems and the proposed didactic experiment, a development was sought starting from a context considered close to the students - water consumption and ways to reduce this residential consumption -, to a local context - treatment and supply of drinking water, water pollution and ways to minimize this pollution – and, finally, a fictitious context – waste treatment – through successively Problem 1, Problem 2 and PEA. With this, the objective is to develop an engagement on the part of the students in the proposed sequence, in view of their familiarity with the themes addressed.

It is also noteworthy that the activities present problems that do not predefine the procedures for their resolution. This fact is evidenced by Problems 1 and 2 not suggesting itineraries for resolution and the experimental activity presenting guidelines that propose laboratory procedures described in a simplified way, and students will be able to reflect on their viability, necessity and linearity. Thus, it is believed to provide autonomy during the activity, leading, among other aspects, to the construction of hypotheses aimed at solving problems, based on different understandings. Another step present in the proposed activities is the exposition and discussion of the resolutions among the students. In this idea, approaches are envisioned to enable students to carry out investigative activities.

Articulação entre a resolução de problemas e a experimentação balizada pela atividade experimental problematizada (AEP): uma proposta para o ensino de química

ABSTRACT

Aceita-se que a dimensão investigativa relacionada à área das Ciências da Natureza pode ser qualificada por meio da utilização de estratégias que permeiem a proposição de situações-problema, ou Resolução de Problemas, e que atividades experimentais apresentam aderência a esta temática, especialmente quando relacionadas ou originadas por problematizações. Por meio deste artigo, apresenta-se uma proposta didático-pedagógica balizada pela associação das metodologias Resolução de Problemas e experimentação, interfaceada pela Atividade Experimental Problematizada (AEP). Esta pesquisa se configura como de natureza qualitativa e, considerando a organização de informações e a produção de novas propostas teórico-metodológicas, abarca também, elementos de Pesquisa Bibliográfica. Considera-se que a asserção desenvolvida é capaz de gerar autonomia e criticidade nos estudantes, propiciando, entre outros aspectos procedimentais-cognitivos, a construção de hipóteses, visando a (re)solução dos problemas propostos, bem como a argumentação científica a partir dessas (re)soluções.

KEYWORDS: Ensino de Ciências. Atividade Experimental Problematizada. Resolução de Problemas.

NOTES

1. This classification is cited in a work entitled “Experimental activities in chemistry: an analysis in textbooks” (SILVA, E.R.A.; PEDROSO, C.A.P.; MEDEIROS, D.R.; VIVIAN, M.F.; GOI, M.E.J.; ELLENSOHN. R.M., 2019).

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BIBLIOGRAPHIC REFERENCES

BASSOLI, F. *Atividades práticas e o ensino-aprendizagem de ciência(s): mitos, tendências e distorções*. **Ciência e Educação**, v. 20, n. 3, p. 579-593, 2014.

BRASIL. ***Base Nacional Comum Curricular***. Brasília DF: Ministério da Educação, 2017.

BRASIL. ***Orientações Curriculares para o Ensino Médio, Ciências da Natureza, Matemática e suas Tecnologias***. Brasília DF: Ministério da Educação, Secretaria de Educação Básica, 2006.

BRASIL. ***Parâmetros Curriculares Nacionais: Linguagens, Códigos e suas Tecnologias***. Brasília: MEC/SEF, 2000.

BRASIL. ***Parâmetros Curriculares Nacionais: Ciências Naturais***. Brasília: MEC/SEF, 1998.

CAMPOS, M. C. C.; NIGRO, R. G. ***Didática de Ciências: o ensino-aprendizagem como investigação***. São Paulo: FTD, 1999.

DELIZOICOV, D.; ANGOTTI, J. ***A Metodologia do Ensino de Ciências***. São Paulo: Cortez, 1992.

ECHEVERRÍA, M.D.P.P.; POZO, J.I. *Aprender a resolver problemas e resolver problemas para aprender*. IN: POZO, J.I. (org). ***A Solução de Problemas: Aprender a resolver, resolver para aprender***. Porto Alegre: Artmed, 1998. p. 13-41.

FERREIRA, L.H.; HARTWIG, D.R.; OLIVEIRA, R.C. *Ensino Experimental de Química: Uma Abordagem Investigativa Contextualizada*. **Química Nova na Escola**, v. 32, n. 2, p. 101-106, 2010.

FIGUEREDO, G.L.; JOSÉ, W.D. Estudo bibliográfico sobre tecnologias digitais no ensino de ciências da Educação de Jovens e Adultos: possibilidades do conectivismo na perspectiva dialógico-problematizadora. **ACTIO**, Curitiba, v. 7, n. 3, p. 1-23, set./dez. 2022.

GALIAZZI, M.C.; ROCHA, J.M.B.; SCHMITZ, L.C.; SOUZA, M.L.; GIESTA, S.; GONÇALVES, F.P. *Objetivos das atividades experimentais no ensino médio: a* *pesquisa coletiva como modo de formação de professores de ciências*. **Ciência e Educação**, v. 7, n. 2, p.249-263, 2001.

GIL, A.C. ***Como elaborar projetos de pesquisa***. 6. ed. Rio de Janeiro: Atlas, 2017.

GOI, M.E.J.; SANTOS, M.T.*S Reações de Combustão e Impacto Ambiental por meio de Resolução de Problemas e Atividades Experimentais*. **Química Nova na Escola**, v. 31, n. 3, p. 203-209, 2009.

LISBOA, J.C.F.; BRUNI, A.T.; NERY, R.M.L.; LIEGEL, M.R.; AOKI, V.L.M. ***Ser Protagonista****: Química, 1º ano*. São Paulo, Edições SM, 2016.

LAKATOS, E.M.; MARCONI, M.A. ***Metodologia científica***. 7. ed. São Paulo: Atlas, 2017.

LOPES, B.J. ***Resolução de Problemas em Física e Química: Modelo para estratégias de ensino-aprendizagem***. Lisboa: LDA, 1994.

LOPES, E.S.; LEITE, F.A.; HERMEL, E.E.S. Experimentation in bachelor's education programs in biological sciences: a look from Fleckian epistemology. **ACTIO,** Curitiba, v. 6, n. 1, p. 1-16, sep./dec. 2021.

MALHEIRO, J.M.S. *Atividades experimentais no Ensino de Ciências: limites e possibilidades*. **ACTIO: Docência em Ciência**, v. 1, n. 1, p. 108-127, 2016.

MARTINS, D.G. *Aprendizagem baseada na Resolução de Problemas articulada à Atividade Experimental Problematizada: Ensino de Química no contexto CTSA do sódio*. Dissertação (mestrado em Programa de Pós-graduação Profissional em Química em Rede Nacional - PROFQui) - Instituto Federal do Espírito Santo, Vila Velha, 2020.

NOVAIS, V.L.D.; ANTUNES, M.T. ***Vivá****: Química*, volume 1. Curitiba: Aprende Brasil, 2016.

PERUZZO, F. M.; CANTO, E. L. ***Química na abordagem do cotidiano***. Vol. 1. 4. ed. São Paulo: Moderna, 2010.

POZO, J.I.; CRESPO, M.A.G. *A solução de problemas nas Ciências da Natureza*. IN: POZO, J.I. (org). ***A Solução de Problemas: Aprender a resolver, resolver para aprender***. Porto Alegre: Artmed, 1998. p. 67-98.

REIS, M. ***Química***. 1. ed. São Paulo: Ática, 2013.

SANEAMENTO PARA PROMOÇÃO DA SAÚDE. Disponível em: <http://www.funasa.gov.br/saneamento-para-promocao-da-saude>. Acesso em: 07/03/2021.

SASSERON, L. H. *Ensino de Ciências por Investigação e o Desenvolvimento de Práticas: Uma Mirada para a Base Nacional Comum Curricular*. **Revista Brasileira de Pesquisa em Educação em Ciências**, v. 18, n. 3, p. 1061–1085, 2018.

SAVIANI, D. ***Pedagogia Histórico-Crítica: primeiras aproximações***. 10 ed., Campinas, SP: Autores associados, 2011.

SILVA, A. L. S.; MOURA, P. R.G. ***Ensino Experimental de Ciências – uma proposta: Atividade Experimental Problematizada (AEP)***. São Paulo: Livraria da Física, 2018.

SILVA, A. L. S.; MOURA, P. R.G.; DEL PINO, J.C. *Subsídios pedagógicos e epistemológicos da Atividade Experimental Problematizada (AEP)*. **Revelli**, v.10, n. 4, p. 41-66, 2018.

SILVA, A.L.S; MOURA, P.R.G; NOGARA, P.A. *Um modelo de sistematização à experimentação no Ensino de Ciências: Atividade Experimental Problematizada (AEP*). **Research, Society and Development**, v. 9, n. 7, 2020.

SUART, R.C.; MARCONDES, M.E.R. *A manifestação de habilidades cognitivas em atividades experimentais investigativas no ensino médio de química.* **Ciências & Cognição**, v. 14, n. 1, p. 50-74, 2009.

ZANON. L.B.; UHMANN, R.I.M. *O desafio de inserir a experimentação no ensino de ciências e entender a sua função pedagógica*. IN: XVI Encontro Nacional de Ensino de Química (XVI ENEQ) e X Encontro de Educação Química da Bahia (X EDUQUI), 2012.

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