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Original article

The contextualization of the teaching-learning process of General Chemistry in pedagogical professional training

La contextualización del proceso de enseñanza-aprendizaje de la Química General en la formación profesional pedagógica

A contextualização do processo de ensino-aprendizagem de Química Geral na formação profissional pedagógica

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ABSTRACT

Contextualizing the teaching-learning process of the General Chemistry discipline in the bachelor's degree in Chemical Education is a demand for further education in higher education, so that students prepare themselves in real situations. In the exploratory study, regularities were observed related to the use of the local context as a concrete space that allows the link between theoretical contents and the daily practical activity of teaching the subject chemistry. This article aims to propose teaching tasks for the treatment of contextualized chemical contents, based on epistemological analysis about how to conceive integrality in pedagogical vocational training, the training is designed to help prepare

Translated from the original in Spanish

people for problems in their daily life and to help them solve problems at different levels of difficulty. The general method of research is taken to be materialistic dialectics, as well as the use of theoretical and empirical methods. The historical analysis, the induction-deduction and the analysis-synthesis allow us to approach the fundamentals, characteristics and main constructs related to contextualization in vocational training and didactics. The use of tools made it easier to understand the initial status and the transformation achieved after the implementation of the strategy. The validation of the methodological indications enabled their practical evaluation. This result is introduced in the first year of the course, in which significant changes are observed in the professionalization, the recognition of the various contexts that enhance training in this specialty, as well as the integrality of the trainees.

Keywords: contextualization; teaching-learning process; chemistry; teaching tasks.

RESUMEN

Contextualizar el proceso de enseñanza-aprendizaje de la disciplina Química General en la carrera licenciatura en Educación Química es una demanda del perfeccionamiento en la educación superior, para que los estudiantes se preparen en situaciones reales. En el estudio exploratorio se observaron regularidades relacionadas con el empleo del contexto local como espacio concreto que permite materializar el vínculo de los contenidos teóricos con la actividad práctica cotidiana de la enseñanza de la asignatura Química. Este artículo tiene como objetivo proponer tareas docentes para el tratamiento de los contenidos químicos contextualizados, sustentados en el análisis epistemológico acerca de cómo concebir la integralidad en la formación profesional pedagógica, de modo que contribuya a la preparación para solucionar problemas de la cotidianidad personal y profesional de diferentes niveles de dificultad. Se toma como método general de la investigación el dialéctico materialista, así como el empleo de métodos teóricos y empíricos. El análisis histórico-lógico, la inducción-deducción y el análisis-síntesis permiten acercarnos a los fundamentos, características y principales constructos relacionados con la contextualización en la formación profesional y la didáctica. La aplicación de instrumentos facilitó conocer el estado inicial y la transformación lograda luego de aplicar la estrategia. La validación de las indicaciones metodológicas permitió su valoración práctica. Este resultado se introduce en el primer año de la carrera, en la que se observan cambios

significativos en la profesionalización, el reconocimiento de los diversos contextos que potencian la formación en esta especialidad, así como la integralidad de las y los educandos.

Palabras clave: contextualización; proceso de enseñanza-aprendizaje; química; tareas docentes.

RESUMO

Contextualizar o processo de ensino-aprendizagem da disciplina de Química Geral no curso de licenciatura em Educação Química é uma demanda do aperfeiçoamento no ensino superior, para que os estudantes sejam preparados para situações reais. No estudo exploratório, observaram-se regularidades relacionadas ao uso do contexto local como um espaço concreto que permite materializar a conexão entre os conteúdos teóricos e a atividade prática cotidiana do ensino de Química. Este artigo tem como objetivo propor tarefas docentes para o tratamento de conteúdos químicos contextualizados, sustentadas na análise epistemológica sobre como conceber a integralidade na formação profissional pedagógica, de modo a contribuir para a preparação na resolução de problemas da vida cotidiana pessoal e profissional, em diferentes níveis de dificuldade. Adota-se como método geral de pesquisa o materialismo dialético, bem como o uso de métodos teóricos e empíricos. A análise histórico-lógica, a indução-dedução e a análise-síntese permitem aproximar-se dos fundamentos, características e principais constructos relacionados à contextualização na formação profissional e na didática. A aplicação de instrumentos facilitou conhecer o estado inicial e a transformação alcançada após a aplicação da estratégia. A validação das orientações metodológicas permitiu sua avaliação prática. Este resultado é implementado no primeiro ano do curso, no qual se observam mudanças significativas na profissionalização, no reconhecimento dos diversos contextos que potencializam a formação nesta especialidade, bem como na integralidade dos educandos.

Palavras-chave: contextualização; processo ensino-aprendizagem; química; tarefas docentes.

INTRODUCTION

Vocational training is a process in which subjects develop social and scientific commitment, flexibility to cultural diversity, and the ability to transcend their context. This process fosters skills such as

divergent and creative thinking, critical and self-critical evaluation, problem solving, decision making and flexible adaptation to a changing world.

Achieving comprehensiveness in vocational training requires, above all, the preparation of graduates who are committed to their work and to the society in which they are inserted, capable of acting with flexibility and transcendence, independently of the specificities of each profession and its contexts.

The university curriculum should make explicit the qualities which are to be developed in students. These qualities should reflect the contextualization of universities according to the complexity of the scenarios in which they operate, not adopting a merely adaptive stance, but promoting deep research as the basis for transforming those scenarios.

The development of the university curriculum oriented towards integrality in vocational training must be aligned with scientific and technological advances, as well as with the redefinition or recovery of values, considering the reality of the environment and its transformation.

Contextualization is a key requirement in the training of education professionals and has been widely studied in the fields of contemporary pedagogy and didactics. This concept has been addressed in relation to the curriculum, technology, communication and components of the Teaching-Learning Process (LEP), with special emphasis on content (Rubio and Gómez, 2021).

In addition, contextualization has been analyzed from the foundations of context and situational learning, as well as as a principle, process, action and/or effect on strengthening the development-oriented teaching-learning process.

In the last decade, research such as those by Zabalza (2012), Gamboa and Borrero (2017), Bautista (2018), Batalloso and Moraes (2020), Cuadréns *et al.* (2021) and Triviño *et al.* (2021) have provided different perspectives on the curricular, educational, Teaching-Learning Process, didactic and content contextualization.

According to Zabalza (2012), curricular contextualization is a process by which curriculum proposals are adjusted to the specific parameters of the various environments, institutions and collectives where they will be applied. This author argues that the curriculum must respond to the contexts

where it is implemented, considering the potentialities, strengths, opportunities and weaknesses of those environments so that education is a true factor of social development.

Batalloso and Moraes (2020) conceive educational contextualization as a broad process of dialogue, communication and exchange of experiences; it seeks to build shared knowledge that generates improvements in the natural context, social and personal, as well as creating and sustaining more tolerant, peaceful and enriching educational and social environments.

Therefore, educational contextualization can be understood as a permanent process of observation, analysis, knowledge and understanding of the structural and relational dynamics of natural, social, political, educational and cultural spaces in a given society.

The curriculum, as a training project of systemic character, assumes a didactic conceptualization that is expressed in its relation to the historical-social context. It is permeated by scientific and technical development and configured according to the needs of the context and students.

The curriculum must have a theoretical foundation from the didactics, based on principles, theories, components and regularities. There is an obvious dialectical relationship between the curriculum and didactics, since there can be neither curriculum without a didactic foundation, nor didactics without a concrete curricular. In the words of Díaz-Barriga (2021), didactics exists to support the curriculum.

In this sense, Triviño et al. (2021) point out the relationship between curricular and didactic contextualization. They propose contextualizing, from the local potentialities, as a concrete space that allows linking theoretical contents with the daily practical activity of students and teachers.

In the case of the Bachelor's degree in Chemical Education, Gamboa and Borrego (2017) thoroughly analyze the curricula, highlighting the need to bring the curriculum closer to the community environment. They recognize the influence of context on the teaching-learning process, as well as the dialogical nature between university and society, and the social function of the university. They therefore conclude that:

> … The design, development or evaluation of the contextualization of the teaching-learning process is not explicitly reflected in the different programs of the discipline and subject of Chemistry Didactics or Chemistry Teaching Methodology; in the study

> plans A, B, C, D and even in the projection of the study plan E; regularity is evident in the design and treatment of the contents from the link with the programs of general basic and higher secondary education. Although, in the realization of this program, in the first study plans, its development in teaching practice is not contemplated, the tendency to increase this link is evident. In addition, the need for a contextualized approach to teaching is implicit in promoting, from its general objectives and content, the developmental learning and the link with life (p. 4).

In an exploratory study carried out in the Bachelor's Degree in Chemical Education at the University of Pinar del Río "Hermanos Saíz Montes de Oca", empirical investigations were carried out using various methods such as: classroom observations, surveys, interviews, visits to work practice activities and the review of documents related to the methodological and investigative work of the first-year group.

These investigations identified weaknesses in the direction of the teaching-learning process of the subject of general chemistry in the various areas of action. Limited use of practical activities was found, as well as weaknesses in methodological work and interdisciplinary relationships within the department. In addition, there was evidence of a disarticulation between the local context and the subject content, insufficient use of the potential of the teaching-learning process through real situations, and a failure to use the local environment as a space for linking the theoretical content of chemistry with the daily practical activity of students and teachers.

Considering the above, the aim of this research was to propose teaching tasks oriented towards the contextualized treatment of chemical contents. These tasks are based on an epistemological analysis which makes it possible to conceive of the whole-train in pedagogical vocational training, with the aim of helping students to solve problems of daily life and the professional field.

MATERIALS AND METHODS

The research was developed from 2022 and covered two academic years of the Bachelor's Degree in Chemical Education at the University of Pinar del Río. For the selection of the population and sample, a universe of 324 people was defined, using the AMPU software. A stratified sample size of 80 participants was determined, with a confidence level of 95% and a margin of error of 5%, corresponding to a value of $Z_{\alpha} = 1.96$.

The intentional stratified sampling method was used, as detailed in table 1, for the application of the selected instruments.

Table 1. Research population and sample

Strata	Population	Sample	Characterization
Students	153	51 (33.3%)	• Forty-six first-year students and five fourth-year students
Teachers	29	29 (100%)	• Sixteen doctors (55.17%): 15 in Educational Sciences and one in Pure Sciences • Thirteen Masters in Pedagogical Sciences (44.82%)
Managers	3	3 (100%)	• A department head • A career leader • A head of discipline

The predominant general method in the research was the dialectical-materialist one, which allowed operating with its laws, categories and principles. Theoretical, empirical and mathematical-statistical methods were used to achieve the proposed objectives.

Among the theoretical methods used, the following stand out:

- Historical-logical analysis, applied to determine the evolution of the General Chemistry discipline in pedagogical professional training and to establish concepts of integration with other disciplines in the current study plan.
- Induction-deduction, which allowed moving from the particular to the general in the direction of the teaching-learning process of General Chemistry, identifying features, assumptions and requirements, as well as developing the corresponding methodological indications.
- Analysis-synthesis, used to identify the characteristics, features and regularities that typify the object of study.

In the empirical field, student performance observation was used to evaluate students' exercise with study guides in various academic activities in real scenarios.

The study variable was defined as the contextualization of the Teaching-Learning Process (LEP) of the General Chemistry discipline, operationalized in two main dimensions:

1. Cognitive dimension
2. Developmental dimension

To complement the research, surveys were prepared and applied to students, with the aim to evaluate the satisfaction rates regarding the training process. Methodological documents belonging to the different teaching groups were also reviewed, and interviews were conducted with teachers, tutors and specialists to identify the potential of the educational contexts in which the PEA is developed.

The mathematical-statistical method was used to process and analyzed all the instruments applied. In addition, a workshop was held to validate the methodological indications, focused on promoting professional reflection, analyzing the results obtained and facilitating decision-making in relation to the proposals formulated.

RESULTS

The current curriculum, the General Chemistry program and the syllabus of the chemistry department teachers were analyzed in a documentary analysis, where they identified as generalities: the leading role of the Main Integrating Discipline (DPI) the need for vocational training and the need to be contextualized in the curriculum. In the analysis of the program of the discipline General Chemistry it was possible to confirm that no methodological actions are needed for the treatment of contextualization.

The curriculum for the career specifies, on the one hand, the need to achieve integration between the organizational components of the PEA (academic, occupational, research and extension) and the need to include contextualized approaches to avoid unnecessary repetition of knowledge that would reinforce the identification and solution of problems specific to the profession. On the other hand,

the design, development or evaluation of the contextualization of the teaching-learning process in the different discipline programs is not explicitly reflected.

Twenty lesson plans were reviewed to determine the practical activities that teachers perform in their classes, as well as those that appear in textbooks and curricula and whether they relate to conceptual nuclei and elements of knowledge from other areas. It was found that 35% of the teachers do what is in the program, 42% do some of the established ones, 58% say there is no reagent, so they do not do any, and 20% link them to everyday life. The methodological work of the department takes on the main category of the department, bearing in mind that the faculty does a horizontal (grade) coordinating job and that the teacher is not subordinate to it but to the department; It must therefore be clear that the teacher must be prepared by him, he must overcome this and review his methodological activity so that in his class, in his subject, the objectives of the degree are expressed in a coherent way in each of the subjects. To diagnose this situation, interviews were conducted with the head of the career department. Among the most outstanding results are:

- The fulfillment of the functions of directing the methodological work of the department has a formal character aimed at fulfilling the training objectives, in correspondence with the subject taught, but still lacking an integrative, contextualized conception.
- The contribution of the teaching staff in its relations with the subjects of the department is recognized, but the structuring of a methodology that contemplates methodological work interrelated with said structure is not evident.
- The department does not play its role as an essential link in establishing contextualization, aimed at the comprehensive training of a university graduate.
- No models are developed to develop methodological work in the department; the activities of the Methodological Plan that are conceived are essentially based on the analysis of the difficulties detected during the previous school year.
- They have never used practical activities as support for contextualized work in the methodological activities of the department.
- The methodological work of the department is the fundamental pillar for the fulfillment of the objectives in the integral training of the graduate of Chemical Education. The lack of exploitation of the potential of this science, aimed at the integral training of students, is due to various causes of theoretical and practical nature; therefore, it is considered that the treatment of this subject is not complete.

In 45% of the revised guides to work practice, the intention is not to contextualize knowledge for solving professional problems with optimal use of the work and research component for task solutions.

Teachers must carry out a thorough methodological work in the various groups, enabling students to assimilate the content and methods of theoretical and practical cognitive activity; as well as the linking of students to research projects which respond, essentially, to the contextualization of Chemistry in different environments.

A six-question questionnaire was applied to 29 teachers, where they had to mark with a cross (X) with the index with which they identified themselves (Figure 1).

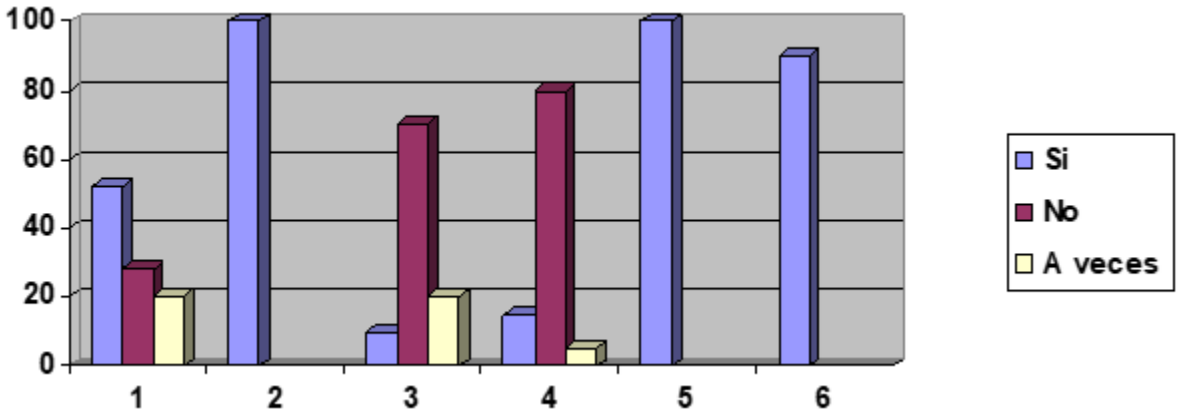

Figure 1. Results of the survey of teachers

The first question in the questionnaire sought to determine whether teachers carried out practical activities in their classes. 52% answered affirmatively, while 20% indicated that they only carried them out occasionally in isolated classes and generally as demonstrations, sometimes not even those contemplated in the course syllabus. On the other hand, 28% stated that they did not carry out this type of activities. The main reasons given were the lack of reagents and other necessary resources.

Regarding the second question, 100% of teachers agreed that practical activities contribute to a better understanding of theoretical content by students, highlighting their pedagogical value.

The third question addressed the contextualization of the content, and 70% acknowledged that they do not do so, 10% indicated that they do, and the rest mentioned that they are not sure. Among the arguments raised, they pointed out that they limit themselves to following the methodological indications established in the program of the discipline.

In the fourth question, 80% of the teachers stated that they do not consider contextualization when designing the class system. They also mentioned that this practice is almost never discussed in the subject groups and that, in the methodological work of the department, it is only occasionally addressed.

With regard to the fifth question, 100% of respondents said that contextualization is useful and necessary because it facilitates the understanding of contents, strengthens the cultural level of students, eliminates the fragmentation of knowledge by subject, and contributes to a more comprehensive and multifaceted training, linking theory with practice and everyday life.

Finally, in the sixth question, 90% of teachers stated that they knew the conceptual nuclei and knowledge elements of the subjects in the area; however, only 10% said they were able to contextualize them in chemistry classes.

In general, the teachers identified several factors that affect the contextualization of the teaching-learning process of chemistry, among which stand out: insufficient self-repair, Lack of time, high teaching workload and other activities that limit the approach to this subject. They also mentioned that contextualization is not adequately worked in the cloisters and year collectives, due to the lack of knowledge on how to implement it.

On the other hand, a questionnaire of four questions was applied to 51 students, who had to mark with a cross (X) the index that best represented their answer (Figure 2).

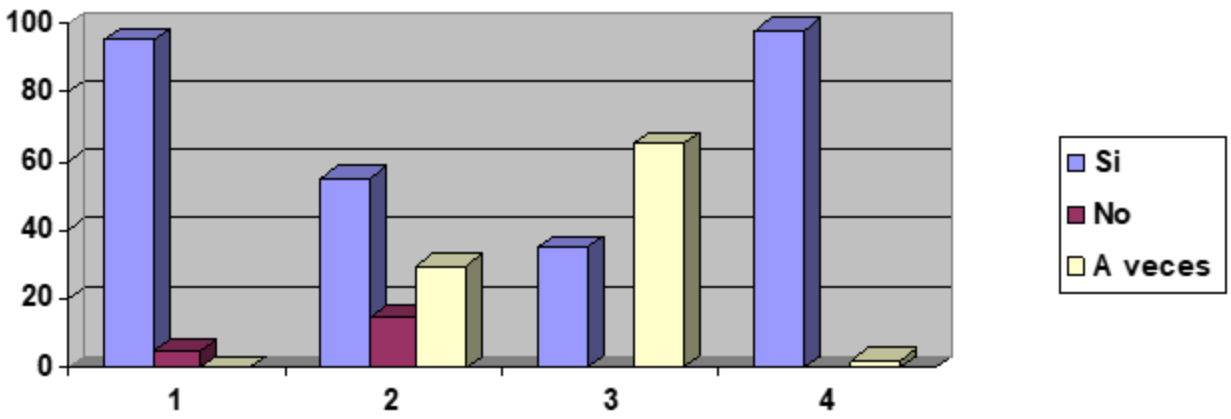

Figure 2. Results of students' survey

The survey aimed to know whether teachers develop practical activities in their chemistry classes and if these are linked with local reality. In the first question, 95% of students said they liked chemistry classes, while 5% identified possible reasons why experiments were not carried out in them.

In the second question, 30% of students indicated that sometimes the activities are related to everyday life. 55% identified participatory games, knowledge encounters and experimental activities as activities contextualized in the Chemistry subject, while 15% did not remember any such activity.

The third question reflected that 65% of respondents perceive that these activities are carried out occasionally and emphasize that they stimulate, motivate and distract them. In addition, 35% believed that these activities develop their skills and abilities, are useful for daily life, allow them to learn more about various subjects and facilitate understanding of the content. However, they recognize that few experiments are carried out and that, in most cases, these are carried out solely by the teacher.

In the fourth question, 98% of the students indicated that no pilot activities were carried out due to lack of inputs and materials, while 2% indicated that they were conducted occasionally.

When carrying out a methodological triangulation of the applied instruments, the following regularities were identified:

1. No contextualized practical activities are systematically carried out.
2. Teachers do not use alternatives to carry out contextualized activities in the locality.
3. The indiscriminate use of demonstration rather than more active strategies predominates.
4. The potential of practical activities for a logical and effective contextualization is not being exploited.
5. There is little use of the conceptual nuclei and elements of knowledge in chemistry with the aim of contextualizing learning and forming more integral graduates.

In response to these shortcomings, a didactic strategy is proposed for the contextualization of the teaching-learning process of the discipline General Chemistry in the course Bachelor's degree in Chemical Education. This strategy, based on teaching tasks (Figure 3), seeks to enhance the application of acquired knowledge to everyday life situations and improve the link between theory and practice.

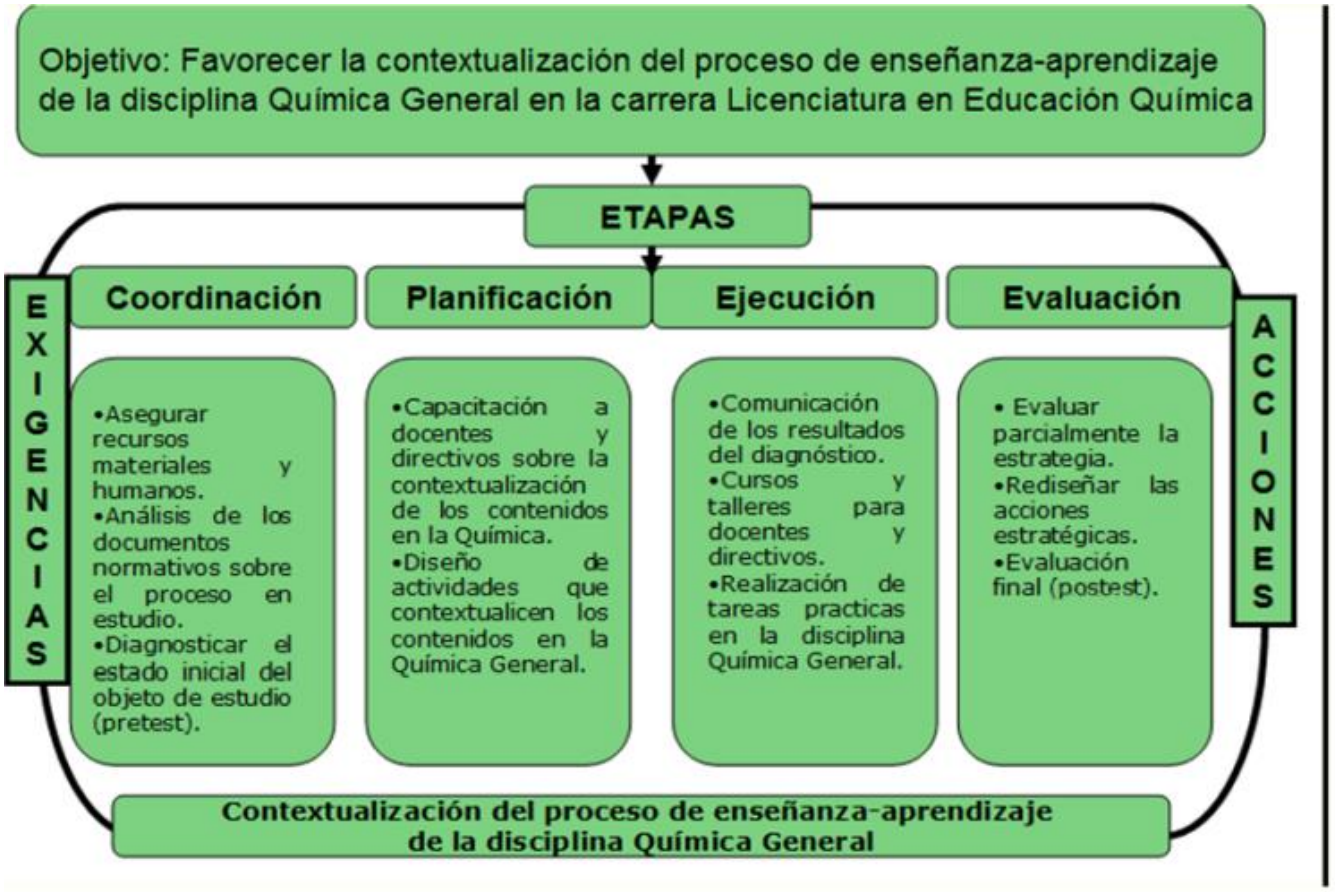

Figure 3. Teaching strategy for the contextualization of the PEA of the General Chemistry discipline

The proposed teaching strategy aims to contextualize Chemistry in the teaching-learning process (TLP) during the first year of the degree, favoring a significant situated learning. This is achieved by carrying out teaching tasks that allow addressing chemical content, in such a way as to favor professional training and the transformation of alternative learning concepts.

Below are some examples of contextualized teaching tasks:

I. Title: The water for drinking

Objective: to apply one of the forms of water purification through a simple experiment, contributing to the future professional performance of students.

Methodological guidelines: This task has the particularity that one part is done during practice, while the last section is oriented towards independent study, which will be reviewed later, and students must present what they have researched to develop oral expression skills.

Activities:

a) Each person should consume approximately two liters of water a day, in addition to the water we ingest through food. Without water, we could not live. Imagine that you are in a place where you do not have access to drinking water. How could you purify the water you need?
b) Perform the following experiment to clean or purify water.

Materials needed:

- A funnel
- Sand
- Cotton
- One inch of soil (approximately 3 cm)
- ¼ liter container

Instructions:

- Pour ¼ liter of water into a container with soil and shake well to mix the water with the soil particles.

- Let the water sit for a moment. What happens to the soil particles?
- Answer: Sedimentation has occurred, which is a way of cleaning the water.
- Place the funnel over a clean container and gently pour the water from the container with the settled soil. What happens to the water as it passes through the funnel?
- Visit your nearest doctor's office, clinic or Hygiene and Epidemiology Centre and find out about the most common diseases caused by drinking contaminated water and the preventive measures that are taken.

II. Title: Environmental contamination by aerial spraying with glyphosate. Toxicology of glyphosate. Chemical activity of the herbicide on plants

Objective: to characterize the locality based on agricultural activities and the use of chemical products applied to crops that can affect water and soil quality, through an interview questionnaire, contributing to the future professional performance of students.

Methodological guidelines: this task should be guided in the first class. To develop it, the teacher can organize the students into teams and direct the work towards some places in the town that he considers most relevant.

Activities:

a) Ask farmers in your area, family members, or during school activities what pesticides and fertilizers they use on their crops.
b) Do you think that the use of herbicides, pesticides and fertilizers should be controlled? Explain your answer.
c) Identifies glyphosate as a substance produced by technology and its environmental impact.
d) Investigate the metabolic pathway of pentose phosphates, the Calvin cycle and the synthesis of aromatic amino acids, determining their chemical formula.

III. Title: Carbon monoxide, an environmental pollutant

Objective: To explain the chemical properties of non-metallic oxides through the structure-property-application relationship of these substances, contributing to the future professional performance of students.

Methodological guidelines: This task will be carried out outside the classroom and will be assessed at the end of the unit. Students will be required to present their results in a seminar.

Activities:

a) Carbon monoxide is a toxic gas that is released during internal combustion in engines.
   - Write the chemical formula for carbon monoxide.
   - What type of bond is present in this molecule?
   - Classify the compound as atomic, molecular, or ionic.
   - Is the solubility of carbon monoxide in water high or low? Justify your answer.

b) Carbon monoxide, in the presence of oxygen, is oxidized to carbon dioxide. Write the equation for this reaction.

c) Mention the measures that have been taken in your country to reduce the presence of carbon dioxide in the atmosphere.

d) Prepare a summary of the use of Chemistry as a science, both for the benefit and harm of humanity, mentioning examples of negative consequences of the inappropriate use of Chemistry on health, the economy and the environment in your area.

IV. Title: Guamá River doubles pollution index

Objective: To explain the harmful effects of sulfur dioxide (SO2) emissions and the chemical reactions involved in the production of acid rain by using traps, contributing to the future professional performance of students.

Methodological guidelines: this task will be developed outside the classroom and will be evaluated with a presentation in a seminar.

Activities:

SO_2 is a gas that primarily affects the respiratory system of children and the elderly, and can even cause death in chronic asthmatics. It also negatively impacts crop yields due to acid rain.

a) Write the equations corresponding to the transformation of SO_2 into sulfuric acid.

b) Describe the process of acid rain formation, identifying the substances involved.

c) Mention four measures that can be taken to protect against the harmful effects of SO_2.

d) In nature, many metals are found in the form of sulfides. What examples can you identify?

e) Mention two measures that can be taken in the industry to prevent contamination by this gas.

Final evaluation:

The final evaluation of the teaching strategy showed significant changes in the previously evaluated dimensions (Figure 4). After applying a methodological triangulation, similarities and discrepancies were found between the evaluations carried out by students, teachers and managers. In addition, the evaluation indices were compared and the following was obtained:

- Initial Assessment Index (IEI): 0.40 (Category IA)
- Final Evaluation Index (IEF): 0.90 (MA Category)

These results reflect a notable advance in the level of learning achieved by students after the implementation of the proposed teaching strategy.

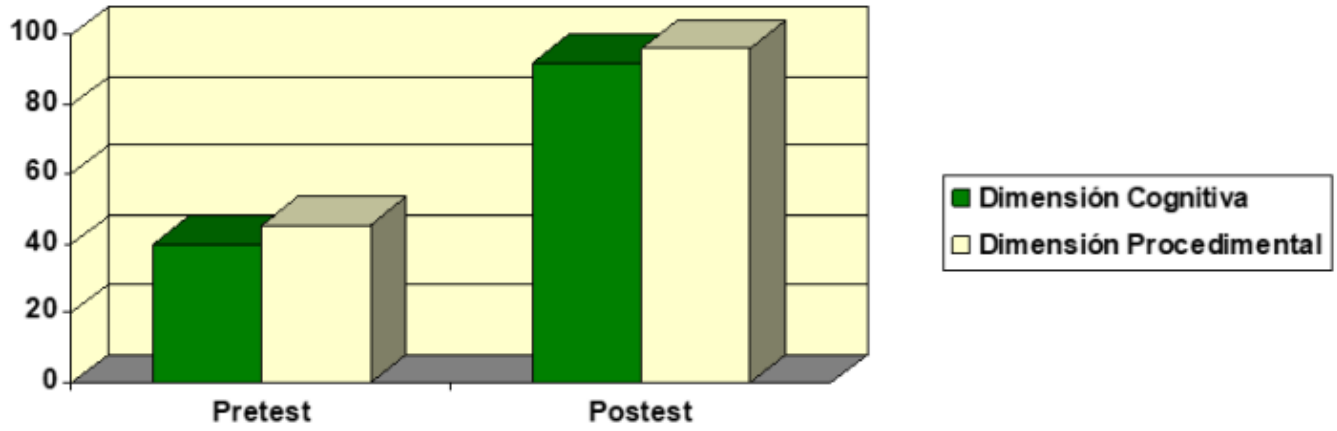

Figure 4. Initial and final evaluation of the application of the teaching strategy

DISCUSSION

The contextualization process in the teaching of General Chemistry highlights the importance of a problematizing approach, which promotes the resolution of practical situations in the environment and favors research, leading to self-learning. The literature highlights that, when students apply their knowledge in real situations (Caballero Hernández, 2020), their cognitive and procedural

development is fostered, as stated by Gamboa and Borrego (2017). However, research also points out deficiencies in the theoretical-methodological approaches of some teachers, who fail to fully take advantage of contextualized teaching tasks or community resources, such as companies and factories near the university (Parga and Piñeros, 2018).

One of the main barriers identified in the research is the limitation in the use of contextualized teaching tasks. This approach is essential to place students in a real context, and its poor implementation limits the effective use of methods such as problem solving, which are keys to the development of research skills. The initial measurement showed these cognitive and procedural deficiencies, which motivated the implementation of a teaching strategy that covered various stages, following what was proposed by De Armas and Valle (2011).

The results obtained from the final or post-test measurement confirm the success of the strategy, reflecting a significant improvement in the skills of students and teachers in the cognitive and procedural dimensions. The strategy of contextualized teaching tasks demonstrated high effectiveness, as it increased students' motivation to carry out practical and experimental activities, both inside and outside the laboratory. In addition, an increase in creativity to solve professional problems and an improvement in the relationship with other educational and community actors was observed.

The examples provided in the study illustrate how to conceive tasks that integrate the teaching of Chemistry from an interdisciplinary and environmental approach. These tasks, in addition to being related to the daily and professional life of students, contribute to the development of intellectual skills through the practical application of the contents, methods and teaching aids.

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Conflict of interest

Authors declare no conflict of interests.

Authors' contribution

The authors participated in the design and writing of the article, in the search and analysis of the information contained in the consulted bibliography.