

## Research in University Teaching of Chemistry: A Case in the Faculty's Initial Training

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### Abstract

With the aim of studying the implementation of research processes in the university teaching of chemistry in the initial training of teachers of this discipline, the observation was made in the students of the classes of courses taught by four teachers in the area of Chemistry Organic of a Venezuelan university. The categories of analysis and interpretation emerged on the questions that were transmitted through a retrospective interview and a semi-structured interview was applied to twelve students of these courses. The categories were 1. The study of problematic situations and 3. The qualitative study of the problematic situations, the study of the concept of research of the teachers and its application in the teaching practice, the consideration of the ideas, the skills and attitudes. the use of the bibliography, the emission of hypothesis, the elaboration of solution strategies and the handling of new knowledge. It was found that the research can be used mainly with the bibliographic information in relation to the topics, which allows the theoretical approaches and the most important practical works and with a lower probability of success. the promotion of scientific skills.

**Keywords:**

Research, Skill, University teaching, Initial teacher training, Chemistry

### La Investigación en la enseñanza universitaria de Química: un caso en la Formación Inicial Docente.

#### Resumen

Con el propósito de caracterizar los procesos de investigación promovidos en la enseñanza universitaria de la Química en la formación inicial del profesorado de esta disciplina, se realizó la observación participante de las clases de cursos dictados por cuatro docentes del área de Química Orgánica de una universidad venezolana. Emergieron categorías de análisis e interpretación sobre las que se indagó a través de una entrevista retrospectiva y se aplicó una entrevista semiestructurada a doce estudiantes de estos cursos. Las categorías fueron 1. La investigación como proceso, 2. Planteamiento de situaciones problemáticas y 3. Estudio cualitativo de las situaciones problemáticas, estudiándose el concepto de investigación de los docentes y su aplicación en la praxis docente, consideración de ideas, destrezas y actitudes, el uso de la bibliografía, la emisión de hipótesis, la elaboración de estrategias de solución y el manejo de los nuevos conocimientos. Se encontró que la investigación se entiende principalmente como la indagación bibliográfica en relación a los temas, que permite los abordajes teóricos y de trabajos prácticos sin una mayor elaboración de hipótesis y de estrategias de resolución por cuanto se tratan de trabajos altamente dirigidos con débil contribución a la promoción de habilidades científicas.

**Palabras Clave:**

Investigación, Habilidad, Docencia Universitaria, Formación Inicial Docente, Química

## A pesquisa no ensino universitário de Química: um caso de Formação Inicial Docente

### Resumo

Com o intuito de caracterizar os processos de pesquisa promovidos no ensino universitário de Química na formação inicial dos professores desta disciplina, realizou-se a observação participante de aulas de cursos ministrados por quatro professores da área de Química Orgânica de uma universidade venezuelana. Surgiram categorias de análise e interpretação sobre as que se indagou por meio de uma entrevista retrospectiva e aplicou-se uma entrevista semiestruturada a doze estudantes de tais cursos. As categorias resultantes foram (a) a pesquisa como processo, (b) apresentação de situações problemáticas, e (c) o estudo qualitativo das situações problemáticas com foco no estudo do conceito de pesquisa por parte dos professores e a sua aplicação na prática docente, consideração de ideias, destrezas e atitudes, o uso da bibliografia, a formulação de hipótese, a elaboração de estratégias de solução e a gestão de novos conhecimentos. O estudo revelou que a pesquisa é entendida, principalmente, como uma indagação bibliográfica sobre os temas, que permite abordagens teóricas e de trabalhos práticos sem formulação de hipótese e de estratégias de resolução por se tratarem de trabalhos altamente dirigidos e com pouca contribuição na promoção de habilidades científicas.

### Palavras-chave:

Pesquisa, Habilidade, Docência Universitária, Formação Inicial Docente, Química.

## Introduction

Science Teacher Training for basic and intermediate education has been a focal point during the last three decades, it has been recognized as a *reflective professional*, away from a perspective of technical rationality (Mellado & Gonzalez, 2000). This emphasis on the thought of the professor, the one who transforms the knowledge of the subject in understandable representations, makes him a builder of a body of knowledge based on his conceptions, roles, knowledge, attitudes, and experiences lived during the initial training, determined by the professional knowledge on how to teach science (Couso, 2002; Vazquez, Jimenez & Mellado, 2007; Garcia, 2009; Cuellar, 2010).

These skills represent epistemologically different knowledge that evolve and constitute a large body of knowledge, where we find the content of science. It refers both to the substance and the syntax of it, in other words, the theoretical knowledge, theoretical frameworks, and internal structure on one hand, and on the

other the rationale and evolution of paradigms, the history-philosophy and nature of Sciences (Adúriz-Bravo, 2011; Garritz & Velasco, 2004; Pozo & Gómez, 2013; Vázquez & Manassero, 2012). This scientific knowledge of the science teacher is organized through his learning experiences, which, in chemistry, as an experimental science, involves the laboratory as a space where the teacher encourages the development of research skills as well as the interaction of theory and practice.

Facing the progressive questioning of teaching and its methods that do not contribute to personal needs nor the progress of science and social development, there are some forces for the renewal of educational structures and contents. From this perspective, research and practice are relevant in order to change the approach focused on teaching to another that is significantly based on learning and that introduces modifications in terms of its meaning and purpose. More than accumulating knowledge temporarily, it must contribute to the development of skills, so the individual can be able to manage them in accordance

with his own interests, as well as individual and collective needs.

In addition, teachers working at an institution are the ones who should admit that scientific research must be cross-cutting to the processes of Teaching and Learning, nurturing the progress of education. If this is understood as a binding element of practice and teaching reflection, it will be used as a mean to apply the following competences in each unit of the curricula: the ability to analyze information, the ability to compare results with other research and consolidated concepts, and the ability to introduce innovations in educational practices. Thus, the aim of research is not to predict and control, but to interpret and understand phenomena.

### Research as Strategy

From a reductionist stance, the experimentation that characterizes both disciplinary and scientific research as well as research approaches developed in scientific learning are focused in mere laboratory work and neglect fundamental aspects for the development of knowledge. In his classic work, Gil (1993) already pointed out that the latter should be the hub of research, since the teaching and learning of Sciences as research refers to addressing problems of interest that help the student build knowledge. By reviewing literature and experimenting in the laboratory in order to interpret conceptual models that explain observed phenomena, the student assumes the position of a researcher (Gil, 1993; Pozo & Gómez, 2013). Thus, it is beneficial to guide the learning of Sciences through research and problematic situations (Belmonte, 2011; Burbules & Linn, 1991; Caamaño, 2012)

*Teaching by problem research* has been characterized by Jimenez-Tenorio and Oliva (2016) as a strategy to overcome *conceptual change*, where there is a variety of proposals, from the inquiry approach to directed research, and it assumes the existence of different phases of scientific work. "Now it is understood as something more aligned with current thinking about the nature of Science: the need of a problem, the existence of a prior theoretical knowledge, hypotheses role, and research design processes," among others (p. 124)

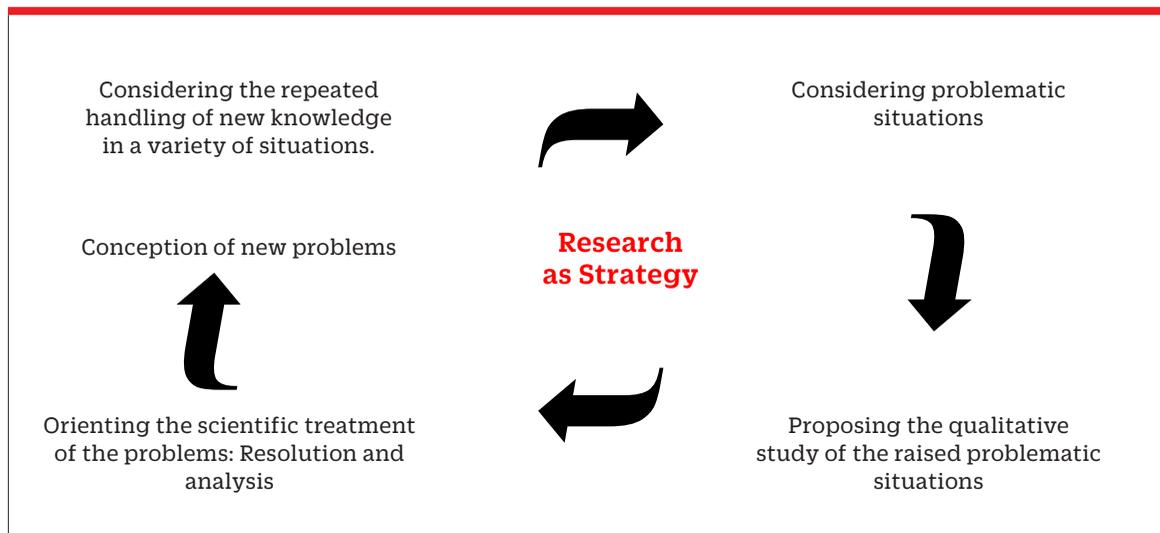
The "new researcher" position would be taken

by students with the accompaniment of the teacher—who poses as a guide in problem solving scenarios, which involves a series of advantages for the student learning process through research, thus, a relevant matter in the initial training of teachers. Ungerfeld (2004) formulate the following:

1. *Using logical thinking and development of the ability to interpret situations*, since it is necessary to be aware of the root or origin of problems in order to solve them, preparing possible alternatives.
2. *Developing designs that allow to solve problems*, since participating in research activities contributes to learning about the feasibility of choosing one way or another to get to the solution.
3. *Learning how to recombine knowledge* in order to explain a reality that has been previously segmented for the sake of its study, leading to the lack of understanding of complex phenomena.
4. *Developing intuitive skills*, which leads the student to intuitive answers and hypotheses.
5. *Developing abilities of their own*, authentic ways of learning capabilities.
6. *Developing critical thinking* so students structure their scientific arguments, transcending the positivism reflected in direct conclusions and answers taken as true.
7. *Using appropriate language*, which is achieved through reading and research, allowing the production of texts and their communication to the scientific community.
8. *Developing curiosity* as research generates the desire to "learn more".

We can say that research enhances the students thought processes of higher-order, as well as the opportunity to transfer knowledge to different situations that initially originated the learning. There are four phases of research as a strategy for the achievement of learning (see Figure 1).

This notion of research as strategy is guiding this study base, since it sustains what has been addressed regarding the construction of knowledge in disciplinary courses for the training of science professors, particularly in Chemistry, where it is important to understand the phenomena



**Figure 1.** *Research as Strategy Elaborated with data taken from Gil (1993)*

and recreate them to generalize and transfer the knowledge to other situations.

**Science Lab and Research**

Within the reforms of the teaching of Sciences in the 1960s, the prevailing idea was that laboratories should not be based on simple demonstrations or verifications of known information, but it should focus on solving problems, in the development of skills needed for research and to provide students the opportunity to discover.

- Based on the experimental nature of Chemistry, laboratory space is an essential element to give the learner the possibility of experiencing the processes of science, using experimentation as a set of activities aimed at conceptualizing the empirical data in the current prospects for teaching science. However, many scholars have criticized the role of the laboratory in the teaching of Chemistry. In this regard, García (2000) presents a synthesis of such postures. Experimental classes in general are excessively loaded, which implies that the students have very little responsibility for their learning and are not able to think for themselves a lot.
- Teachers emphasize on the correct answers, so the laboratory tends to verify known information.

- Laboratory work is a purely academic formality where different experiences seemingly disjointed and without any application are performed.
- The amount of instruction that the student receives is one of the elements that impede the achievement of real learning, since the experimental activities execute such instructions without understanding what they have done.
- The unclear and not productive form of practical work gives them little educational value.
- The work in the laboratories seek for verification, which is made by the students to be followed as if it were a cooking recipe.

Hence, these critics show a need to change the picture, and ponder on what is being done in the laboratory. Many of the agreements at global level regarding experimental classes seek that students develop abilities, skills, and habits, because one must teach skills for the acquisition (learning strategies) and application of the taught knowledge (problem-solving) from a research perspective. For this reason, as the aim of this study, it was proposed to characterize the processes of research promoted in Chemistry university education in the initial training of teachers in this discipline.

## Method

### Design

This qualitative study was developed under the interpretative-constructive paradigm (Álvarez-Gayou, 2009; Dezin & Lincoln, 2012; Flick, 2004), taking into account a case study of multiple participants for its development (Neyman & Quaranta, 2006).

### Participants

The field of study was formed by universities that educate chemistry professors in the central area of Venezuela. Key participants were selected by comprehensive sampling, allowing “a priori definitions of the sample structure,” as well as “defining the totality of possible cases so that all can be integrated into the study” (Flick, 2004, p. 77), covering theoretical reasons and looking for a set of cases that would allow to account for the phenomenon to be analyzed. Therefore, the criteria considered initially were:

- Homogeneity: All teachers should work at a university level; whose workplace is the classroom and chemistry laboratory in the Chemistry Department. Gender: male/female.
- Heterogeneity: Teachers can have a bachelor or teacher initial training as well as being in a pre-diploma or specialization, or fourth level (master's or doctorate) degree. They can also teach any subject related to the area of knowledge of organic chemistry.
- Inclusion: Teachers with three or more years of experience in university teaching are included in the study.

Then, four participants were selected for instrumental reasons (Simons, 2011) on the basis of the evident willingness and acceptance of participation. These teachers were all in the knowledge area of organic chemistry, identified with the nomenclatures of Informant Teacher A (IT-A), Informant Teacher B (IT-B), Informant Teacher C (IT-C), Informant Teacher D (IT-D) with the following characteristics:

- IT-A; IT-B, and IT-D: Professors specialized in Chemistry. Master's in Education with mention in Teaching

- IT-C: Bachelor's degree in Chemistry. Candidate for a Master's degree in Education.

### Instrumentation

Regarding the techniques and instruments to produce information, the following are specified:

#### ■ Participant observation

Categories emerged based on what was observed in the classes of participating teachers, which oriented the research work using a log/notepad. This technique, according to Couso (2002) allows the alternation of the degree of observation and participation according to the moment in which they are required. The researcher enters the field to produce the data and reflects on what happens, depending on what they want to see.

#### ■ Retrospective interview to key informant teachers

A script of questions based on the categories and subcategories that emerged from the observations made to the theoretical and practical classes as mentioned above was designed. The information was transcribed, constituting units of analysis, which were later synthesized for their study.

#### ■ Unstructured interview to key informant students

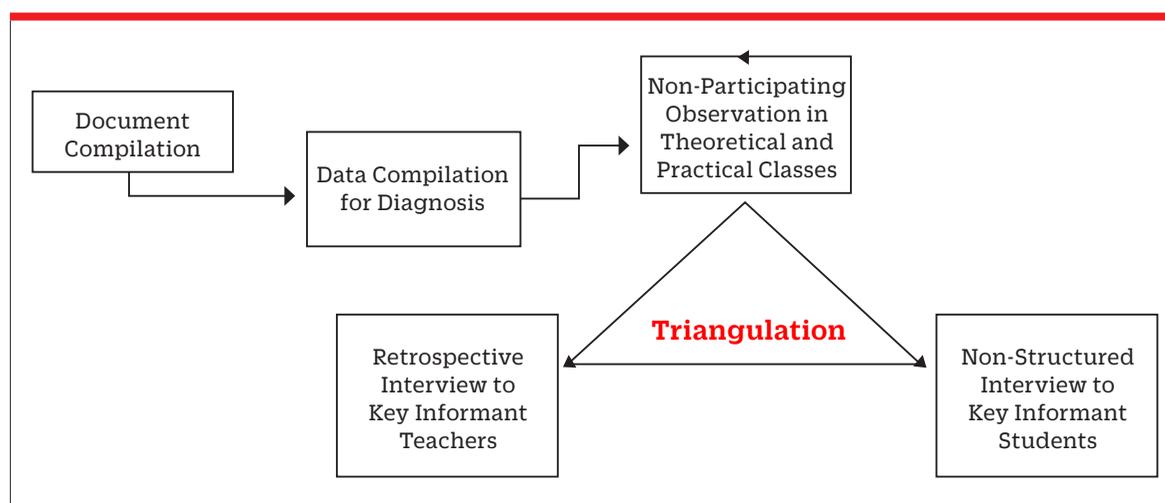
In order to inquire about research as a strategy for teaching of key informant teachers, there was a need to know another perspective: the student one. For that purpose, during the period of participant observation, three (3) students were selected by each teacher, who were requested to collaborate as key informants for this research. Thus, a semi-structured interview was carried out (Canales, 2006; Simons, 2011) in relation to a *list of relative issues* based in what was observed previously in the classes.

### Procedure

For the achievement of the objective established in this study, and after the participant observation, the system of categories and subcategories was created (see Table 1), and then questions of retrospective and semi-structured interviews were generated.

**Table 1.**  
*Categories and subcategories of the study*

<p><b>Research as a Process</b> Framework for action involving teachers and students while developing the curricular content corresponding to the subject.</p> <p><b>Approach to problematic situations</b> Structured and planned teaching actions in a sequential way and purpose-oriented.</p> <p><b>Qualitative study of problematic situations</b> Assessment and approach for means of resolution</p>	<p><b>Concept of research and its application in teaching practice</b> Organizing framework from which research is understood and acts accordingly in the teaching role</p> <p><b>Consideration of ideas, skills, and attitudes</b> Engagement that the teacher makes from the contributions and skills of the students to the investigative action</p> <ul style="list-style-type: none"> <li>• Use of literature</li> <li>• Issuance of hypothesis</li> <li>• Preparation of solution strategies</li> <li>• Management of new knowledge</li> </ul> <p>Scientific thinking skills promoted through the evaluation and approach to developing means of resolution</p>
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**Figure 2.** *Methodological Procedure*

The analysis of the information was developed through the analysis of content, such as a set of interpretative procedures of communicative products (messages, texts or speeches) that come from unique processes of communication previously registered and, based on measurement techniques, are meant to develop and process relevant data on the same conditions in which texts have been produced and that works by systematic and objective procedures for the description of the content of the messages.

The information provided in the questionnaires

and semi-structured interviews follow the model proposed by Canales (2006) that refers to the process of structural discourse analysis, which includes an initial moment of re-composition of structures, which will identify the basic units of sense and the relationships between them; a second moment in the dynamization of structures where relationships found in a model of action are organized, which allows to direct the practice of subjects; and lastly, a final moment for triangulation, which makes it possible to establish the emerging aspects of reflections according to Figure 2.

## Results

After data reduction, the corresponding coding and categorization of information produced through observation and interviews to informant teachers and students, we proceeded to the triangulation of information by each category and subcategory in the study after a previous discussion which is shown here below.

### The concept of research and its application in teaching practice

For key informant teachers, research is conceptualized as a process of search and examination of information, which is also considered as an essential tool for learning and knowledge building. However, at the time of using it in class, such process is limited to the student solving exercise and problem guides, reading or checking theoretical aspects that are indicated by the teacher at best. Then, two things can happen: it is specified what the students should read or they are allowed to read a general outline on the topic to discuss.

Teachers indicating students to read about a problem-context was not seen at the participants observation. This is an important aspect, as teachers stated that research is essential to university life, issue that is in accordance with the contributions of different investigations and revealed by some as the perfect way of university education (Podesta et al., 1982. cited in Ungerfeld, 2004). This author also states that its goal should be scientific training and the development of a creative mindset at university level, that no longer promotes *studying more*, but achieving understanding from a methodological perspective, i.e. *how to study* and *how to learn*.

That is why the next question arises: is research really being promoted in the classroom through readings and by sending reading assignment to students? Research can be incorporated into teaching from activities that require greater commitment, far superior to reading for the next class.

In a similar logic, this situation also affects laboratory time, as teachers recognize that there is “no research” in it and that practices contained in the manual are reproduced every semester, a fact that is consistent with what the students mentioned and what was observed. This allowed us

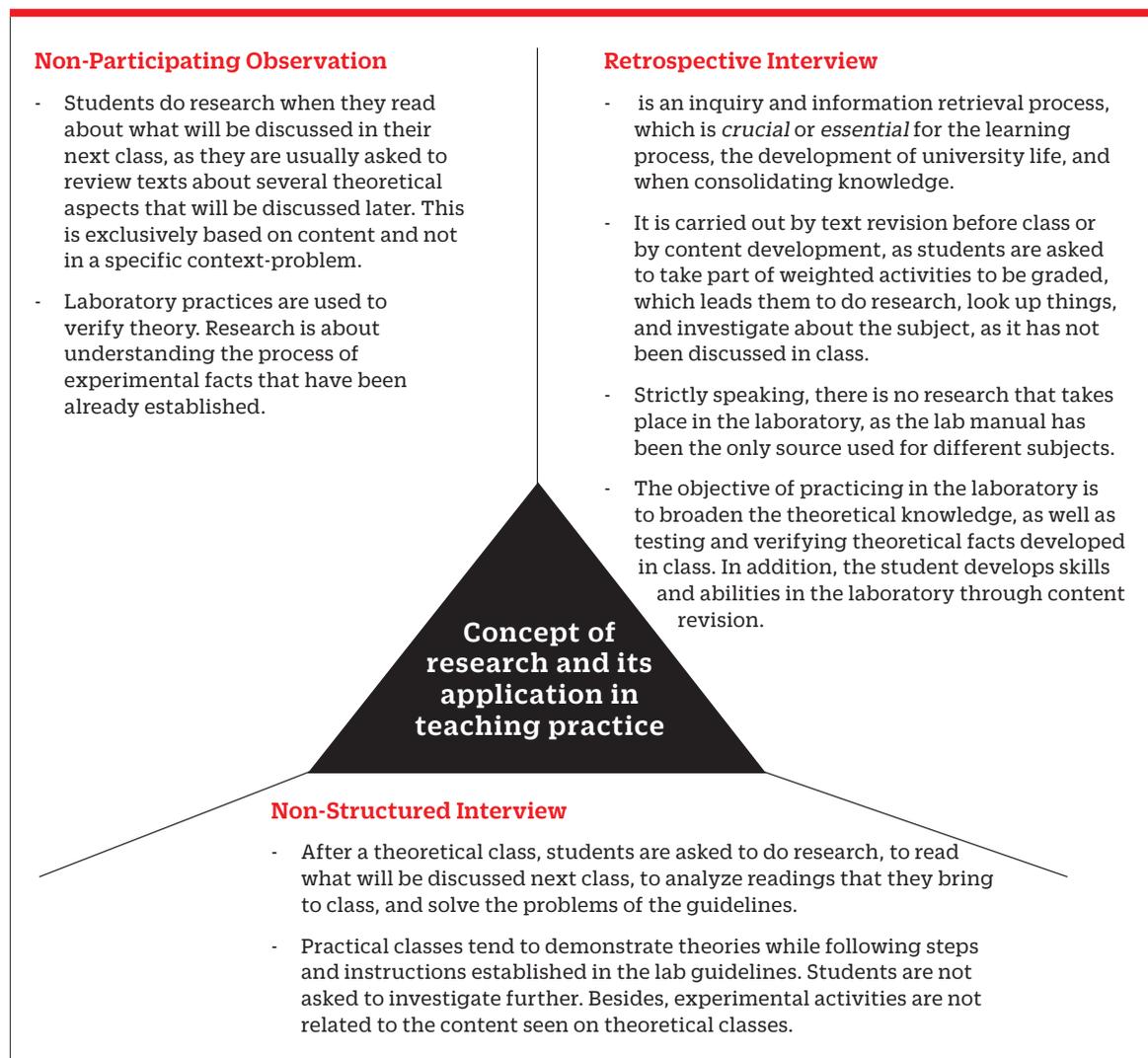
to know that practices that are carried out aim to test the theory. However, the contents covered in the laboratory are rarely related to those treated in the theoretical class.

### Consideration of ideas, skills and attitudes

Regarding this aspect, when the teacher poses problems taking into account how students perceive the world, their skills, and attitudes, they can generate interest and a preliminary conception of the task to develop (Gil, 1993). However, the way in which key informant teachers consider these ideas, skills, and attitudes is *listening* to the mean of resolution students reach once the problem has already raised in the theoretical class. It often has to do with solving numerical and algorithm-based, repetitive and closed problems, which is a traditional view of teaching chemistry that prevents the proper interpretation of the resolution of problems as a strategy. At an experimental level, they recognize the *fear* they feel when a student suggests an idea to be carried out in the laboratory, since it is usually done out of curiosity and without any sustenance or theoretical guarantee.

Then, there is a dual situation: the teacher does not consider the students contributions in theoretical classes to propose problems and thus increase interest and encourage participation. Nonetheless, when these ideas flow in the experimental area, they are not considered because the uncertainty from which they are raised, even when they know that they come from curiosity and could therefore trigger a series of authentic learning situations. The foregoing is warned by Jimenez-Tenorio & Oliva (2016) when they point out that those previous ideas are useful, so the problem makes sense, as well as the formulation of hypothesis, and the orientation of the entire research process.

In terms of the development of skills and attitudes, the produced information reveals that it is not part of the discourse of the interviewed teachers (Figure 4). In that way, there is only a concern in laboratories to indicate students *what to do* and *how to proceed*. Thus, we identify the absence of the development of approaches to questions, working hypotheses, experimental designs, management of data and analysis for interpretation and elaboration of conclusions, as well as the



**Figure 3.** Category: Research as a process. Subcategory: Concept of research and its application in teaching practice

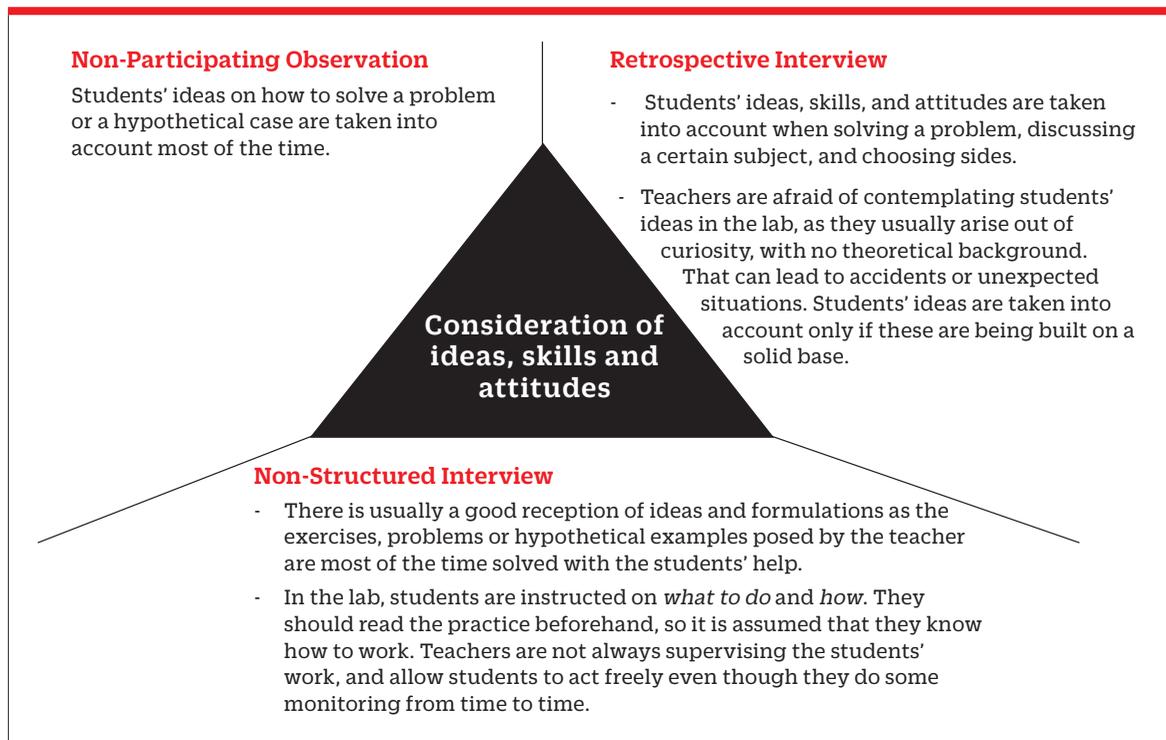
corresponding meta-reflexive review as a good description of the research process in terms of the students' procedures and attitudes (Ferrés, Marbá & Sanmartí, 2015).

**Use of literature**

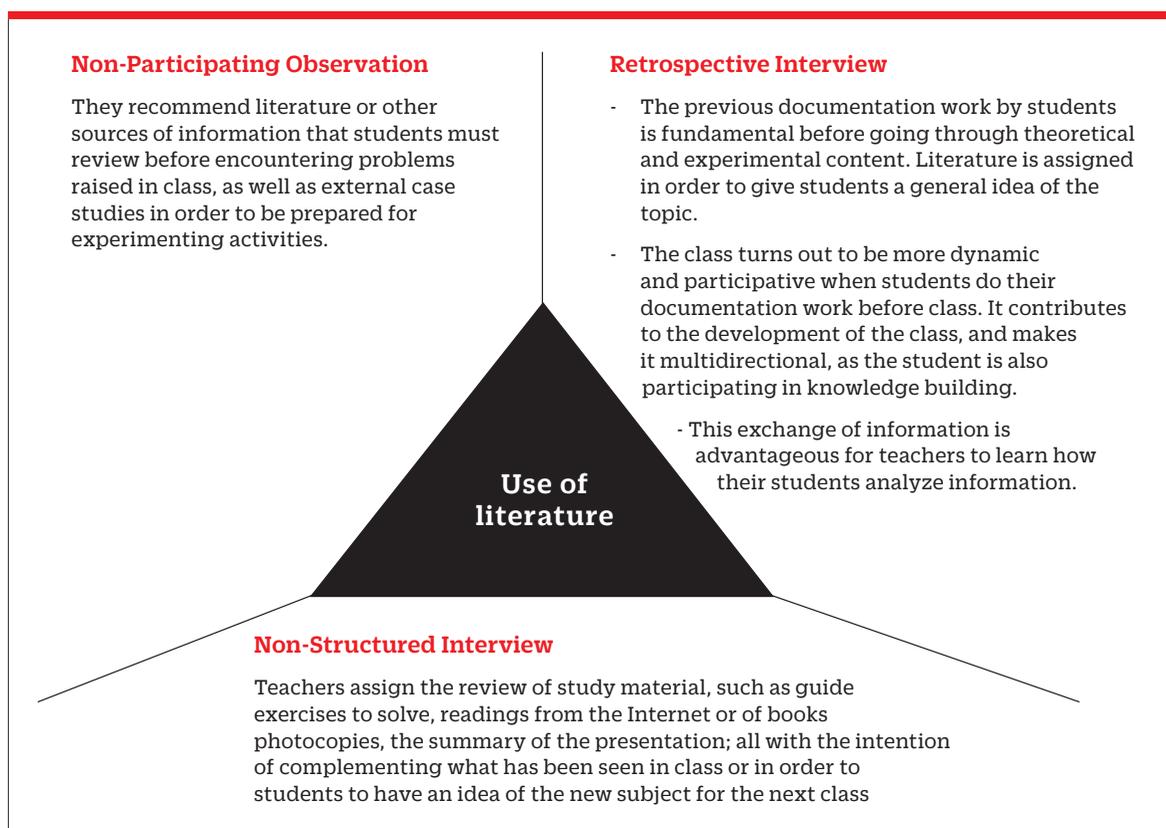
Teachers involved in research allow students to review various bibliographical sources so the class can be more participatory and dynamic, making it a space in which the student also participates in the construction of knowledge (see Figure 5). In this sense, documentation is important in order to qualitatively deal with a problem of study, as it is necessary to have a knowledge base. Therefore, besides suggesting revision of texts of the sub-

ject of organic chemistry, they should invite students to explore the additional material such as problems and exercises, slides in Power Point presentations, and online material. When reflecting on the use of new technologies in the teaching of chemistry, we can identify that the Internet is an excellent tool for finding specific information; however, as the student finds information so easily accompanied by excellent drawings and schemes, they may believe that will be sufficient when presenting work and for documentation.

Nevertheless, when the teachers in question request the literature review of the student, these do not consider themselves as a part of the process of the construction of knowledge, because they



**Figure 4.** Category: Approach to problematic situations. Subcategory: Consideration of ideas, skills, and attitudes



**Figure 5.** Category: Qualitative study of problematic situations. Subcategory: Use of literature

consider the goal is to help them to complement what has been seen in class so they have a notion of what will be discussed in the next session.

### Issuance of hypothesis

Key informant teachers induce in its students the formulation of hypothesis, as evidenced through the observation in the participants that they are capable of producing hypothesis for situations of analysis and when solving practical problems, for what they must have notion of the scientific principles that govern raised phenomena. Therefore, they often must orient the issuance of hypothesis, because students tend rarely to make it by themselves, and that is where information from non-structured interviews converges (see Figure 6), as it is widely known that they feel that the solution to the problems is offered by the teacher, with little participation from them. Thus, the above can relate to the issues raised by Poggioli (1999) about directed learning that focuses on experience guided by an expert—the teacher—and skill development occurs gradually thanks to the modeling of the execution of the task, the use of the expert's execution procedures and, finally, feedback from the execution of the students in order to bring them to such level of skill.

However, since making justified explanations, or hypothesis that express a relationship between variables, or models that express their understanding of reality, it is one of the educational goals of the investigative processes for teaching Sciences (Martínez, Jiménez & Lucio, 2015). It is relevant for the teachers to know how to formulate them to avoid orienting them: A hypothesis is a guess of something possible or impossible that has a consequence; and the working hypothesis is the one set provisionally as a research base.

When students generate hypotheses is because they have developed some investigative processes, such as framework based on a problem—usually provided by the teacher about the explanation of some phenomenon or problem/exercise solving in the course of the class—observing its nature, and then proceeding to analyze and select what is relevant, gathering all the possible data for its resolution. Another process is the one that takes place once the data has been collected, as the student is able to produce a provisional explanation

that describes the reasons that generate the problem in question in the simplest way possible, or the same solution, such as a brief statement or a mathematical formulation, respectively.

### Drafting Resolution Strategies

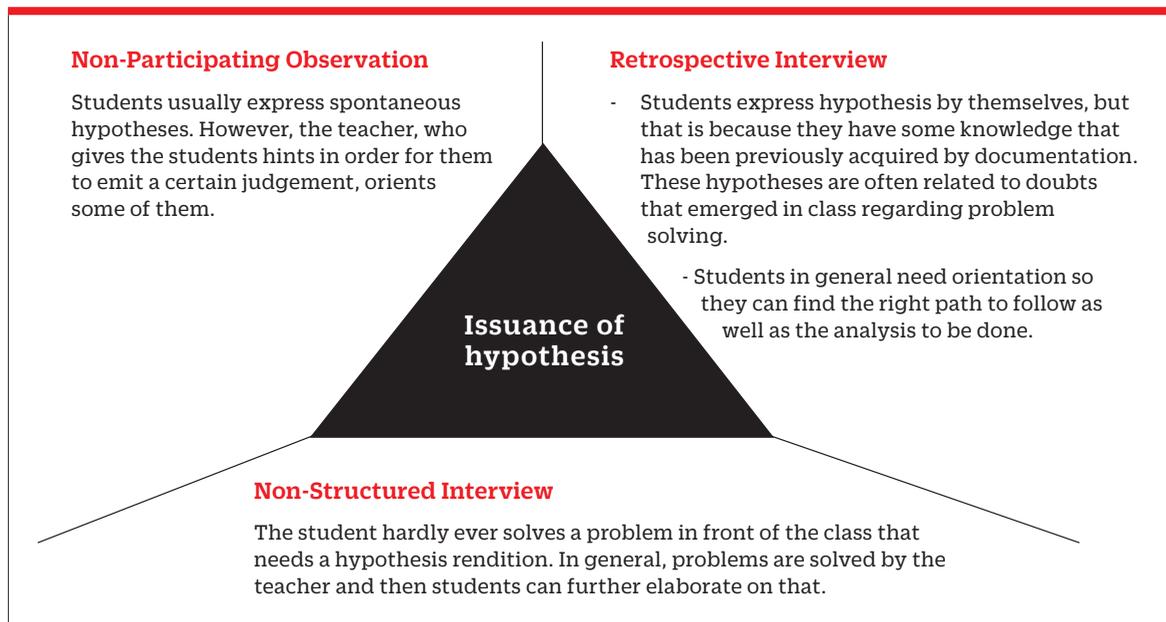
Teachers—at their discretion—allow students to prepare the way of solving the situations that have been presented; however, what is proposed in class are usually exercises where data is perfectly explicit, and what is missing is the solution for the puzzle. It is not about real problems, as the means or ways for its resolution are clear. This is typical of classic statements of science matters, as in the case of chemistry to be used to expose all the data required for the resolution and indicate what mathematical models, are nothing more than *exercises of recognition* of an algorithm already used by the teacher to solve it, or search for formulas in which replace all the data and get the answer (see Figure 7).

On the other hand, in the experimental area, students follow the guidelines dictated by the laboratory manual. Therefore, there are no truly problematic situations that demand heuristic processes or of divergent thinking to solve them, as those raised by Poggioli (1999).

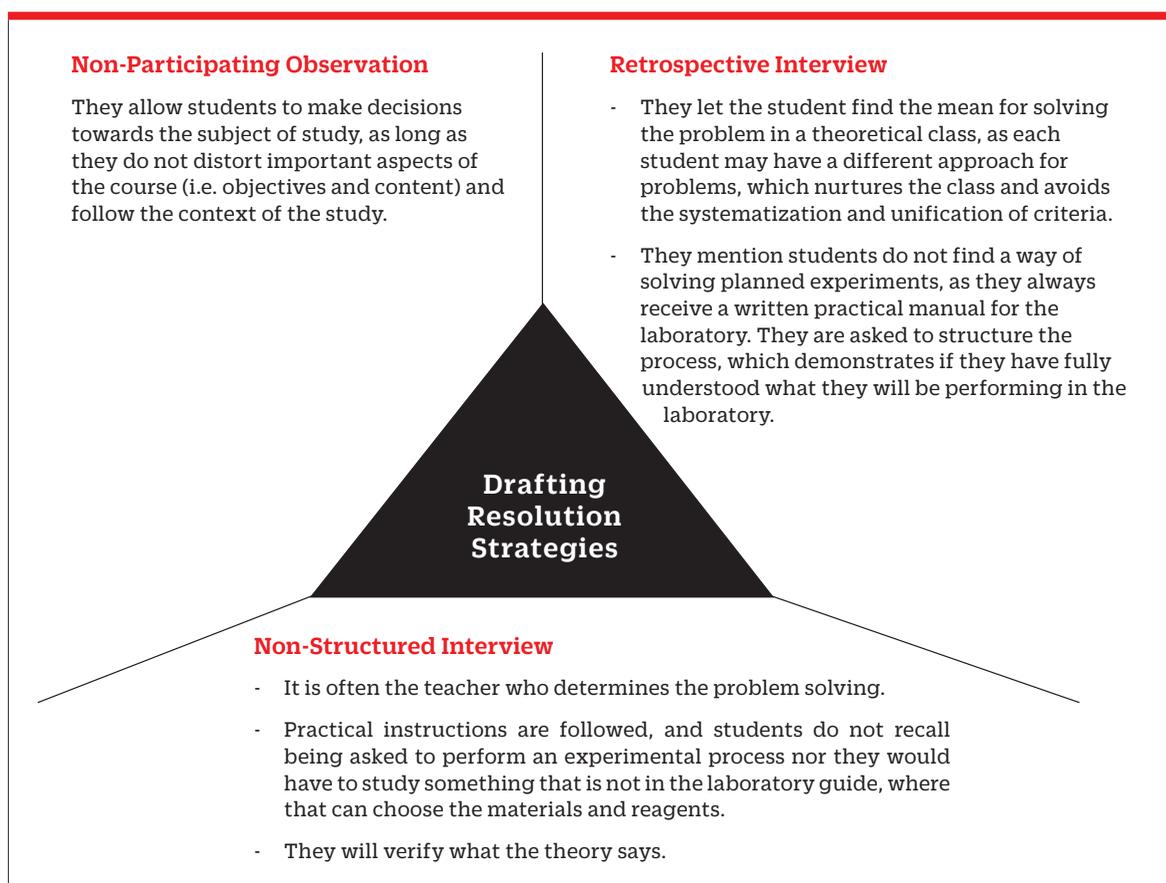
## Discussion

Key informant teachers have a notion of the research process very similar to the one it is established in the literature. However, its development in the teaching of Organic Chemistry is weak within the theoretical context because the student only reads and reviews material prepared by the teacher; and in the context of laboratory, research is limited to reviewing theoretical aspects pertaining to the practice to be developed: to run a test of pre-laboratory. The above seems to be a contradiction with the systematic way of approaching knowledge through authentic activities that promote understanding and evolution of scientific ideas.

Specifically in practical work, it is not encouraged to promote research activities from an analyzing proposal, characterized by theory verification, with little or none correlation with con-



**Figure 6.** Category: Qualitative study of problematic situations. Subcategory: Issuance of hypothesis



**Figure 7.** Category: Qualitative study of problematic situations. Subcategory: Drafting Resolution Strategies

tent developed in theoretical classes. This is relevant in times where *scientific inquiry* approaches, strategies such as *problem-based learning*, or *research based teaching* learning models are present in the literature of science teaching, and are demanded from secondary education to teachers in training, where “poor didactic training school science teachers have, in general, (and that, incidentally, tend not to recognize) have transmitted it to their students (high school teachers) and they also have transmitted it to their students” (Cartañá & Comás, 1994, cited in Campanario, 2002).

Therefore, proposing activities that will allow to promote research, such as open problems and experimental cases, that require the student in question to consider synthesis, analysis, resolution, among other cognitive and cognitive-linguistic skills.

The ideas of the students are considered once the teacher raises what is considered a “problem”—who generally provides all data for its resolution, making it highly predictable, algorithmic—in the outline of their possible solution, but not in the construction of problematic situations to be discussed during the class—nor the ones that can be done in the laboratory for fear of unexpected accidents.

The reviewed case promotes the discussion of literature in the classroom, on the basis of what their students review from the bibliography to make the class more dynamic and participatory. However, they may have the risk that 1) student checks only one type of source such as the one provided by the web technology platform, which sometimes shows inaccurate information and not in a serious way; 2) by not reviewing other sources such as texts or journals, the student loses the opportunity to compare the collected information and reach more elaborate and powerful conclusions; and finally, 3) the student has a poor information processing due to an incomplete reading of the material given by the teacher before discussing the content, or simply does not check it. For this reason, it would be ideal if teachers design activities to guide them in the use of bibliography through issues of interest that contribute to the investigative development.

Additionally, it is allowed the elaboration of hypotheses for problem solving with pencil and

paper during the theoretical approaches by the students that, as it is directed by the teacher, underestimates the ability of the student. This occurs only in theoretical classes, as noted. Usually there is no chance to reflect in the laboratory due to its pre-established nature: the results are known.

Teachers can sometimes prepare the mean of solving the *exercises* posed in class, while in the experimental area, designing a mean of solving the problem of study seems paradoxical because, in general, the laboratory does not represent a problematic situation to work on.

During classes, teachers allow their students compare the results obtained from the resolution of exercises so they can check if they are correct or not. An opposite situation takes place in the laboratory due to lack of time which, as the teachers mentioned, can even affect the full achievement of the experimental part, thus the possibilities of creating new knowledge in the students are minimized. An ideal would be to constantly compare the results of experimental works, in a way where knowledge is shared and the process of feedback-regulation of what has been learnt is guided, as well as its transfer in a variety of situations.

Thus, implementing research to chemistry teaching in initial teacher training of the case study is far from the forms and purposes that literature in Didactics of Experimental Sciences provides today. A traditionalist nuance is recognized in the teaching of these contents in the case, which is usually a model to be replicated by teachers in high school education, after the training. Therefore, it is recommended to continue reviewing what is happening in university education of the discipline involved in initial training programs, since Galiano and Sevillano (2015) warn that students in chemistry teaching training should be able to learn to ask, question, create problems and provisional answers, review chemical knowledge in the light of the prevailing theoretical frameworks in a moment of history. These reflective processes are roads that they should take while in training.

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