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## THE ROLE OF EDUCATIONAL RESEARCH IN TEACHING CHEMISTRY

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### ABSTRACT

An overview of the relationship between educational research and teaching chemistry is presented, covering the opportunity areas between production and science popularization (dissemination of scientific knowledge). Knowledge apprehension and appropriation are also discussed in the educational context of UNAM, in Facultad de Estudios Superiores Cuautitlán. Links between scientific and pedagogical training are defined by considering educational research as a means to broaden the theoretical and methodological options for chemistry teaching.

#### Key Words:

Educational Research, Chemistry Teaching.

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## INTRODUCTION

This paper provides an overview of certain opportunity areas related to chemistry teaching in the current educational context. If teaching processes are defined by content and ways of teaching, then the educational practice supposes getting to know reality, learning and the problems that arise within. This extends the analysis of the teacher's role and consequently, the ways of educational research as a fundamental axis for teacher training (Bizcarra, 2009). By constructing an object of study that lays within real chemistry teaching processes, circumstances in which experiences and proposals redefine the teaching conditions are created. Having this in mind, it is evident that our academic work with high – school and college teachers needs to recognize the characteristics of teaching practices and the main theoretical, technical and epistemological issues.

### A series of opportunities areas have been identified

- The social role of a science teacher

- Dissemination of scientific knowledge as information, learning and construction.
- Lack of entailment between science teaching, history and scientific philosophy.
- Relationships between the teacher and educational research (knowledge accumulation).
- Links between the teacher and the scientific investigation processes.
- Teacher's efforts to recognize teaching practice dimensions.
- The attempts to establish links between didactics, scientific training and science production with a theoretic – methodological approach to teaching that if possible, guarantees the articulation to define new ways of teaching science in general, and chemistry in particular.

Scientific knowledge dissemination plays an essential role to replicate values, knowledge, abilities and attitudes that set up conditions and life expectations, as well as job related functions, investigation, and continuous feedback related to content and ways of learning in institutions (Varilla, Ramos and Carrizo, 2005). Teaching practice supposes being aware of the reality, learning and the problems that arise as a start-up

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point to elaborate, enrich and restore curriculum, demanding a commitment for didactics, reality being taken into account (Onwuegbuzie and Collins, 2007). Chemistry didactics, upto now, has been sheltered in the practice of educational models that seem to be efficient but that encases several difficulties in knowledge dissemination. This is due primarily to the lack of clear comprehension-explanation mechanisms for those theories that are being reproduced. A spectrum of obstacles is then built, especially when ways or organizing scientific rationality for knowledge dissemination are concerned (Obaya and Delgado, 2001). Scientific reasoning and knowledge accumulated by scientific research are key elements to incorporate into teaching. If one wants to disseminate organized information, it is necessary to teach people to think of what they are receiving (knowledge thinking). Scientific knowledge and its popularization acquire then relevance. A fundamental aspect is to reproduce scientific training, based upon reconstructing the logic beneath scientific thought. Eventhough this has always been present in the classrooms, it has been conditioned to the contents' levels of information that are taught within teaching practice and according to our current reality (Olguin and Obaya, 2016). If all knowledge supposes the presence of a socio.historical context, it should be disseminated in such a way that the richness of the context in which knowledge was achieved is considered without leaving theory aside. Thus, the theoretical product and the logic with which it was created are integrated. Theory of knowledge considers that developing science means to accumulate concluding statements about reality, which are tested, verified or refuted.

### **Learning and Knowledge construction in Teaching**

In Mexico, where most population is young, people need to be involved at schools to contribute in scientific training processes. When people learn to explain and apply their knowledge of the physical world by practical means, they extend an innate ability of perception and curiosity, incrementing their abilities and needs for thinking, creating and therefore, investigating. The protagonic responsibility of the students activity as a key element to learning has been related to the tendency that considers the knowledge construction process as an individual act. As such, it becomes an exclusive product of the interaction between the subject and the object of study, relatively far away from the influence of other people, including teachers. Even if the self-structuring activity is the basis of knowledge construction and has its own intrinsic laws, it is not implied that the teachers functions and psychopedagogical interventions have to be left aside. It should be intrinsically linked to didactics so as to provide an operational direction. More over, there are reasons to establish that the teacher's and the peers' influence make the student's activity structurant, having a bigger influence over his learning (Espinoza and Salfate, 2006). This supposes displacing the focus of the structurant activity as the object of study to the interaction processes between the teacher, the students and the content that trigger and promote the activity, not limiting only to school learning but including change processes typically linked to evolutional development as well. This shift has a great relevance in the teacher's role and his functions as a learning guide or facilitator, since it is his duty to create optimal conditions within the classroom. What should the teacher do, in concrete, to guide and facilitate learning through the problematization perspective? Despite the diversity of proposals that didactics offers nowadays, it is imposible to

provide one right answer to this and other questions. In this way, difficulties that arise to implement and generalize pedagogical practices inspired in constructivist principles are evidenced in chemistry learning (Gómez-Moliné and Sanmartí, 1996). How many areas of opportunity related to scientific training become apparent in chemistry didactics? How many tasks are opened to the concretion of this pedagogical discipline? It results evident that to generate a didactics construction of chemistry from this new perspective, we need a new learning proposal where dextresities, values, norms, attitudes, interests are captured (Parga and Mora, 2014). In many occasions, the student is pulled away from his own thoughts and discoveries from his own learning. The teacher not only does not precise the desired learning proposal, but he also manifests the willingness of not inciding over the students learning and gives way to his own learning process. By identifying the self-structuring activity as the individual activity, it is sometimes forgotten that the learning and teaching processes are in essence interactive, with three aspects that converge: the student that is involved in the learning process, the object(s) of study that constitute the learning content and the teacher that favors learning (Schmelkes, 2001). Considering these three aspects, the basic unit analysis of the learning-teaching process is not the student's individual activity anymore. Rather than that, we need to consider the articulated activity of the student and the teacher as a means to perform learning activities (López, Blanco and Serrano, 2017). The self-structuring activity of the student is generated, developed and occurs as part of an interpersonal activity.

Hence, the student's activity that is at the basis of the knowledge construction process is set within the interaction teacher – content – student (Parga and Mora, 2014). Educational research will then be confronted with two priority areas of opportunity: identifying the guidelines and interactive sequences that contribute to the knowledge construction process, and showing, if possible, the mechanisms by which the interaction teacher – student incides over the self-structuring activity of the student as a consequence of knowledge formal logic (Schmelkes, 1993). Thereby, in Piaget's theory, the cognitive development is conceived fundamentally as the emergence of an individual's internal plan (the balance of operational structures) in such a way that the interpersonal relationships, its characteristics and repercussions depend on the level achieved in that emergence, instead of being in its origin (Yilmaz, 2013). The challenge consists of integrating in the same explanatory frame the student's self-structuring activity and the interactive processes. Even if it is perceived that both aspects are intertwined, they have not been integrated satisfactorily in an explanation of school learning (Tojar and Serrano, 2000). A new chemistry didactics should propose a pedagogical intervention that resolves the articulation between reality appropriation (apprehension) and knowledge appropriation (learning).

### **Enfasizing the apprehension processes of the subject (student) implies**

- Contrarresting the tendencies of conceptual blockages and Foster the problematizing approach.
- Favoring critics to the accumulated knowledge, being conscious that knowing a lot of theory does not necessarily implies thinking about reality.
- Questioning scientific cosmovisions as an idea of a real or absolute explanation.

- Developing the observation in a methodological grouping that conducts to recognize limits of knowledge.
- Setting basis for new angles to observe reality, new concepts and ways of thinking as a product of interacting with reality in the sense of interpreting what is possible.
- Discovering ruptures and lead to gnoseological conditions and constructing scientific reality.

### **Possible relationships between content and teaching methods**

Undoubtedly, one of the most common problems that educational research does not consider are the links between content and teaching methods, not only in chemistry but education in general. It is a reality that after at least three centuries, the questions: What knowledge is needed to be disseminated? And How to disseminate it? are still a challenge among our socio-cultural-educational context. Nowadays, the relationship between content and teaching method includes and synthesizes all the pedagogical issues (Pérez and Pessoa de Carvalho, 2000). In the particular case of teaching chemistry, the answers presented upto now are far from being satisfactory. Paradoxically, science has generated its own myths and rituals. An example of this is precisely teaching science, where the pretension of creating the scientific spirit in students is still a wish. Moreover, it is considered that teaching chemistry has not fulfilled its role and the gap between the chemistry being made and the one disseminated in schools is greater with time (Pérez y Pessoa de Carvalho, 2000). How do we pretend to create scientific thinking, if we, chemistry teachers settle with repeating knowledge without linking it to the method that originated it? Why is chemistry taught in a repetitive, memoristic and stereotyped way, forgetting its structure and history? The questions *What to teach?* and *How to teach?* cannot be posed without considering *Why teaching?* and *What to teach for?* Deep down, *What to teach?* and *How to teach?* are linked to *what is knowledge?* and *How does a person disseminates, constructs or appropriates knowledge?*, besides from *What social and educational goals are met?* *What determines content and method?* And *Under which criteria is content selected and hierarched?*

### **Some content and method notions in teaching**

In order to understand the possible links between content and method in teaching, we take as an initial premise (Onwuegbuzie and Collins, 2007) that it is necessary to start with unfixed concepts or unschematized since we are in a dynamic situation at excellence. In this sense, we consider three elements or conceptual resources that are determinant for reflecting upon:

- The links between content and method in teaching can be found in two essential moments: curricular and classroom.
- The relationship between content and method can be seen through the successive transpositions that occur in the moments in which the knowledge that arises from investigation becomes part of teaching.
- The dynamic between the links among content and method can be perceived in the intergame posed between two areas of rationality: the normativity and the substantial.

The first element makes reference to the situation previous to action, the formal curricular moment which is ideal, hypothetical and concerned to the planning task. The teaching moment constitutes the real and daily action, the in situ teaching event. In the second element, the concept of transposition allows us to observe that the content and method undergo a series of adjustments or adequations in the moments mentioned before, which include parameters such as the subjectivity within selection, hierarchy and organization, as well as the interpretations that can be made in the planning and the teaching processes (Espinoza and Salfate, 2006). The third element is closely related to the previous one, allowing the identification of two schemes: the implicit normative rationality in the formal curriculum and the substantive rationality displayed in school practice, given by the normativity. (Tojar and Serrano, 2000). Both schemes are usually in conflict due to the teacher's interpretation of his daily tasks.

### **Classroom moments**

The curricular proposal is reassessed in terms of the interpretation that the teacher does from his knowledge, experiences, the physical conditions of the classroom, the students' individual characteristics and the students heterogeneity during the pedagogical process (Giammatteo and Obaya, 2018). Another fundamental transposition is found here: the logic of the subject defined in the conceptual structure is presented as the formal factor that orients the process (Espinoza and Salfate, 2006). Nonetheless, even if not altered, this represents the external content object to communication and appropriation. This, in turn, is confronted with the accumulated content from both teacher and student, and it is this confrontation that defines the real logic of the process. As can be noted, the relationship between the subject's logic and the process's logic are presented as articulated but they are not the same. The first one orients the process and the second one determines the dynamic among knowledge dissemination and appropriation. The logic of the process is understood as a series of activities where interventions and interactions between teacher and students take place. These interactions are impossible to be predicted.

In this real dynamic situation, it is possible to identify links between content and methods: from the teacher's knowledge, where content is linked to a sui generis way of dissemination and the accumulated students' knowledge, to sui generis construction or appropriation, where the congruence among both is more than ideal. We coincide with Gramsci in that "the most fascinating content and methods become inert if the teacher is not able to bring them to life". We believe that different logics are involved in dissemination and appropriation, but both are articulated in a unique and lively process. The act of teaching is essentially a creative event, and therefore, original.

### **Scientific rationality in teaching**

Considering the commitment to establish its own continuity, scientific knowledge popularization becomes one of the biggest problems in science. Therefore, getting someone closer to scientific knowledge, incorporating it into learning, facilitating its appropriation and internalization become fundamental purposes that provide themselves objects of study for scientific investigation which will require several levels and dimensions in teaching.

In consequence for chemistry, both the investigation methods in teaching and cognitive methodologies and strategies for science popularization are fundamental (Obaya and Delgadillo, 2001). In such a way, the problem of knowledge is not only the production or application of scientific research. Rather than that, the reflection for disseminating its contents in teaching, coming up with several strategies for its preservation and development, is required. Chemistry is rationally historical. The explanation of knowledge determinations and constructions within this discipline arises from the context in which they were originated, considering the conditions of rupture and continuity of scientific thought that are conceptually established in scientific revolutions.

### **To establish the bonds between didactics and scientific training, it is fundamental to reflect upon**

- Scientific investigation
- Scientific investigation training
- Chemistry teaching

Nowadays, educational research in science teaching represents the search for theoretical, methodological and technical options. This orients didactics to an articulation with rational processes which constructed science in different socio historical contexts. In this way, teaching which contrasts paradigms and gives answers to different questionings from epistemologists would favor its development. As a starting point, it is necessary to emphasize that educational research does not try to solve the problems within scientific investigation, but it does try to solve the following issues (Artigue, 2003):

- Scientific knowledge popularization, supposing that both trainer and trainee in relationship with content will try to understand the rationale and formal logics of knowledge construction, considering the social context and reality conceptualization of the historic and epistemologic dimensions.
- The problems related to search and theory specification, focused on an explicative and qualitative analysis that fulfills the basic theoretical investigations and prioritizing the concepts and knowledge production that the teacher generates in the classroom
- The interest of finding new links between pedagogy and chemistry is due to the concerns that arise by observing the didactics implications with scientific training and knowledge popularization, recognizing that chemistry has specific knowledge and formal deductive logics that are configured by symbols, signs, signals, that establish a particular language (Gómez-Moliné and Sanmartí, 2000) to which add up specific attitudes and abilities. This exclusive epistemological process has been scarcely revised in the different educational levels and it is evident that it requires a bigger training process.

### **Based on the previous aspects, there are three elements to be considered simultaneously**

- To observe the students' learning evolution within a didactic sequence, identifying the most relevant moments (progress, errors, blockages, restructurations, regressions, etc.)

- To dispose of a model that describes the psychological processes implied in the students appropriation of the content. In other words, to have a cognitive functioning model that allows to formulate hypothesis regarding knowledge construction reflecte don the learning evolution. This element is key so that the interaction analysis overcomes the characterized description. To establish the interaction sequence that occurs during a didactic sequence, contemplating the psychological processes that occur in the cognitive functioning including the different interaction categories.

### **Conclusion**

The current panorama establishes a possible context for educational research in teaching chemistry since the dimensions and levels previously mentioned are an object of study that try to explain the relationships between them, considering the comprehension of historical conscience and the incorporation of scientific reasoning while empowering the sense of critical theory in its construction. This enhances the critical use of theory, highlighting the social needs for science popularization, diffusion and communications, tasks which are priorily educational. School and didactics should teach thinking, considering essential factors such as: curiosity, intuition, perception and imagination as basis for analysis and hypothesis construction (Burke and Onwuegbuzi, 2004). Consequently, contrasting leads way to creativity, reality apprehension and knowledge appropriation to make scientific investigation formative processes from the most basic parts of the school system. In such a way, the dimension of teaching chemistry emphasizes diverse investigation processes in different school settings. As an example, the problems for restructuring divisions of chemical knowledge in the curriculum, the acknowledgment of procedures that select new contents in scientific investigation to be incorporated in the curriculum, the redefinition of science popularization conditions in chemistry, the processes of educational modernization among others were discussed. Among these options, one of the most interesting ones is the integrated teaching of chemistry that can adopt several forms and could be discussed further in another essay.

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