CHEMISTRY TEACHERS PEDAGOGICAL CONTENT KNOWLEDGE ON CHEMICAL EQUILIBRIUM

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Abstract

Chemical Equilibrium is a central concept in the learning of chemistry and remains one of the most difficult to teach and to learn. Therefore, this topic is the subject of many studies in science education with different goals: to know the difficulties of student learning, misconceptions, explanations for these errors, and so on.

Two years ago we present in EDULEARN10 a teaching-learning sequence built in the framework of School Science, to propose the construction of a Chemical Equilibrium model based on thermodynamic (phenomenological) arguments and in agreement with constructivist theories. In the design of that sequence, we take as a starting point the alternative conceptions, prior knowledge and the various cognitive abilities of the students. Our hypothesis was that in this theoretical framework, the students could construct the concept in a better manner.

In the past few years, teacher educators and educational researchers have emphasized the need to developed the pedagogical content knowledge (PCK) of the professors, as a useful tool to enhance learning and although his importance, there are many few articles about the PCK of chemical equilibrium.

Because of that, before testing the sequence with students, we decided investigate the PCK of five professors of high school and four undergraduate Mexican teachers. Among other things, we want to know what are de activities that the teachers proposed to overcome the difficulties in teaching this concept. In two of the group of the teachers selected, we will probe the sequence designed. To document the PCK, we decided to use the methodology proposed by Loughran and coworkers.

Keywords: Chemical equilibrium, teaching learning sequences, thermodynamics, PCK.

1 INTRODUCTION

Chemical Equilibrium is a central concept in the learning of chemistry and remains one of the most difficult to teach and to learn [1]. Therefore, this topic is the subject of many studies in science education with different goals: to know the difficulties of student learning, misconceptions, explanations for these errors, and so on.

Teaching Chemical Equilibrium implies a great challenge because of its specificity and complexity. To understand equilibrium, it is necessary to know and use other specific and abstract concepts, which also have important learning difficulties, for instance: chemical reaction, stoichiometry and kinetics, to name a few (Fig. 1).

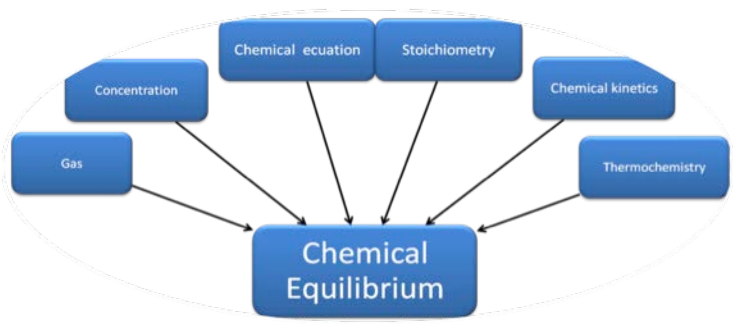

Figure 1. Conceptual need to start with Chemical Equilibrium.

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That is why their study occurs until the final year of chemistry at high school and also because of the abstract nature of the concept, since is necessary the use of formal thought for its understanding. Wheeler and Kass [2] in their research, argue that a student's who has not reached an advanced level of formal thought is incapable of understanding that chemical equilibrium is a dynamic process: two chemical reactions with opposite directions.

We can say that educational practice has shown serious difficulties in learning and teaching of chemical equilibrium and it is convenient to propose another way for teaching it via educational research.

Two years ago we present in EDULEARN10 a teaching-learning sequence built in the framework of School Science, to propose the construction of a Chemical Equilibrium model based on thermodynamic (phenomenological) arguments and, in agreement with constructivist theories. In the design of that sequence, we take as a starting point the alternative conceptions, prior knowledge and the various cognitive abilities of the students. Our hypothesis was that in this theoretical framework, the students could construct the concept in a better manner.

2 A TEACHING LEARNING SEQUENCE IN THE FRAMEWORK OF THE THERMODYNAMIC FOR LEARNING CHEMICAL EQUILIBRIUM

The educational research reports different difficulties in learning and teaching of chemical equilibrium.

Most of the reported difficulties [3] arise when students lack the prerequisites for understanding chemical equilibrium or when they use previous knowledge inappropriately. Frequently:

- students may believe that mass and concentration mean the same thing for substances in equilibrium systems,
- some students conceptualize chemical equilibrium as a product of opposing forces,
- chemical equilibrium shifts are viewed by many students as an application of Newton's 'action-reaction law' to chemical reactions. Linear causal reasoning is usually embedded in those Newtonian applications,
- a further extension of mechanical ideas to chemical equilibrium may explain why some students may believe that the concentrations of the reactants equal the concentrations of the products,
- lack of mathematical tools and reasoning, which often leads to a poor understanding of the Equilibrium Law, and so on.

The way in which chemical equilibrium is traditionally teaching is also cause of many of the students difficulties, since in introductory chemistry lessons, chemical reactions are presented as proceeding to completion, taking place in one direction. Yet, in the case of chemical equilibrium, three basic ideas should be considered [4]: 'incomplete reaction', 'reversibility' and 'dynamics'. These three concepts are difficult for the students to grasp; for when they begin the study of chemical equilibrium they are aware that 'all' reactions take place in only one direction and that a chemical reaction stops when one of the reactants disappears. As a consequence, students face several cognitive conflicts when dealing with chemical equilibrium reactions.

On the other hand, the teaching of this concept is made parallel to the Le Chatelier principle (LCP) and science education research have shown how, apparently reasonable applications of LCP, can result in incorrect predictions about the effects of changes in concentration, volume, pressure, or temperature on chemical systems at equilibrium. On the other hand, the construction of this concept is based on kinetic arguments that have not been deducted or explained.

Taking the above into consideration, we design and implemented a teaching-learning sequence built in the framework of School Science, to suggest the construction of a chemical equilibrium model based on thermodynamic (phenomenological) arguments. We take as a starting point the alternative conceptions, prior knowledge and the various cognitive abilities of the students. In agreement with constructivist theories, we considered in this design that the students must establish meaningful relationships between chemical theories, practical activities (to perform their experiences) and languages and also that is the teacher, with appropriate teaching, who should facilitate them to do this in a meaningful way. Our hypothesis is that in this theoretical framework, the students can construct the concept in a better manner.

The school scientific activities are designed to propitiate a new dynamic of class based on the communication of ideas and teaching of chemistry as a modeling process. A first approximation of the sequence is shown in Figure 2 and the scheme is based on the proposal of Lijnse and Klaassen [5, p. 546].

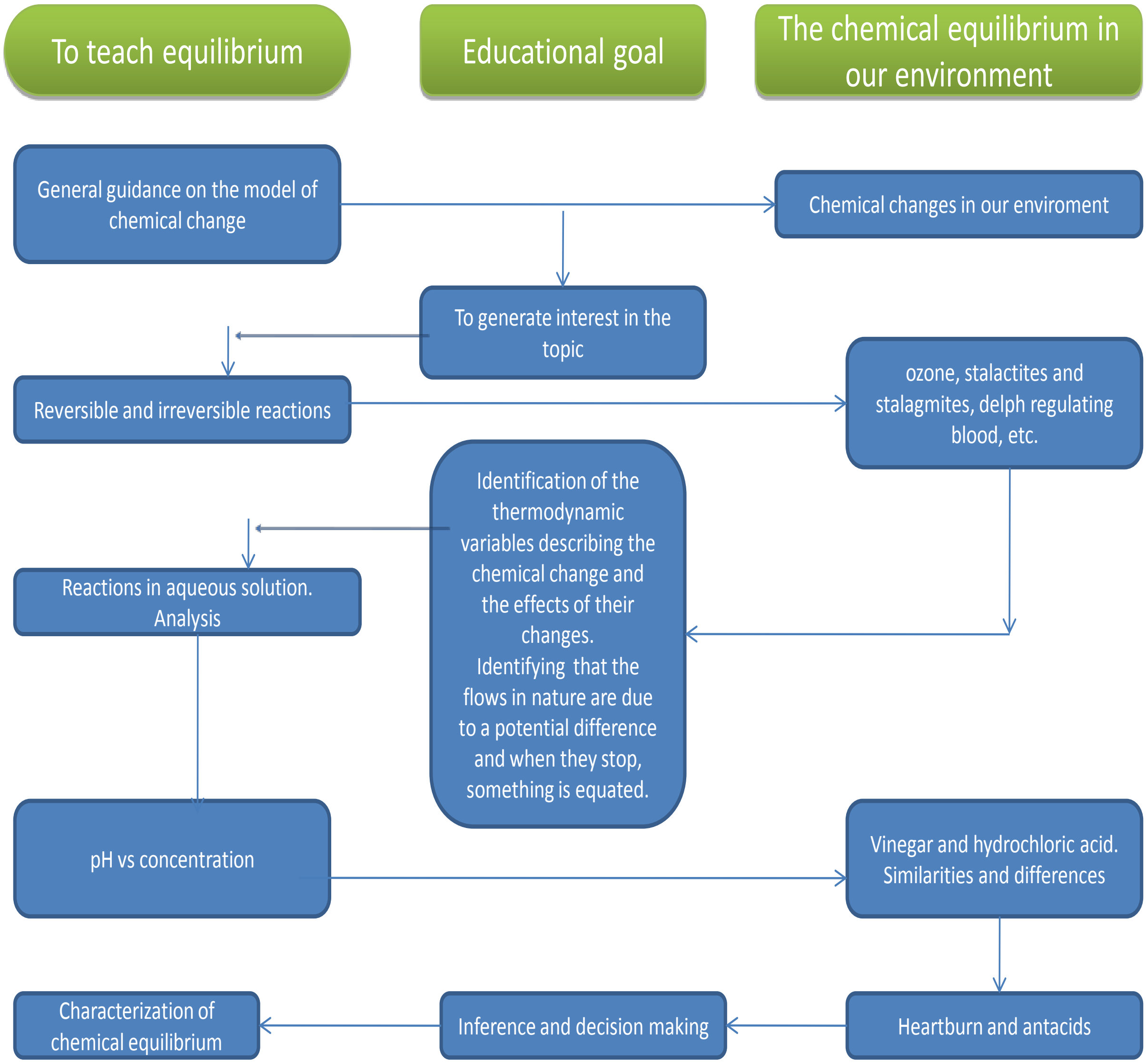

Figure 2. A teaching-learning sequence for chemical equilibrium.

3 THE PEDAGOGICAL CONTENT KNOWLEDGE OF CHEMICAL EQUILIBRIUM

In the past few years, teacher educators and educational researchers have emphasized the need to developed the pedagogical content knowledge (PCK) of the professors, as a useful tool to enhance learning [6, 7] and although his importance, there are many few articles about the PCK of chemical equilibrium [4].

Because of that, before testing the sequence with students, we decided investigate the PCK of four professors of high school and four undergraduate Mexican teachers. Among other things, we want to know what are de activities that the teachers proposed to overcome the difficulties in teaching this concept. In two of the group of the teachers selected, we will probe the sequence designed. To document the PCK, we decided to use the methodology proposed by Loughran and coworkers [8].

The method that they proposed comprises two tools: Content Representation (CoRe) and Pedagogical and Professional experience Repertoires (PaP-eRs). In the congress we will present the analysis of the CoRe's of the eight professors mentioned above.

Initially, teachers discussed by groups, about which were the "central ideas" to teach chemical equilibrium. We use the term in the same way that Mulhall y coworkers [9] use "big ideas": "Big ideas" is a term often used in science to describe an idea that has had a profound impact on the ways scientists understand and conceptualize the world. Our use of the term is not synonymous with this: we mean the science ideas that the teacher sees as being at the heart of understanding the topic for the particular class under consideration. (Nevertheless, a big science teaching idea may also be the same as a big science idea.)

As a result of this teacher's discussions, the big ideas that identified the group of high school teachers were: previous knowledge, reversibility and dynamic equilibrium, equilibrium constant and factors affecting chemical equilibrium (Table 1).

Table 1. Content representation (CoRe) of the high school teachers.

Name				
School degree				
Age				
Teaching experience (years)				
Central ideas	**Previous knowledge**	**Reversibility and dynamic equilibrium**	**Equilibrium constante (Kc)**	**Factors affecting the chemical equilibrium**
Please answer as fully as possible, for each of these core concepts, the following questions:				
Why it is important for students to know this?				
Difficulties/limitations connected with teaching this idea.				
Difficulties/limitations connected with learning this idea.				
Teaching procedures and didactic methodologies (analogies, metaphors, examples, demonstrations, reformulations, experiments etc.) do you use for student to identify the importance of this central concept?				
Specific ways for ascertaining students' understanding or confusionaround this idea.				

On the other hand, the group of undergraduate teachers identified as big ideas the concepts (table 2): spontaneity, reversibility and equilibrium; stoichiometry and reaction progress; thermodynamic properties (S and G, for instances) and chemical potential (μ).

Table 2. Content representation (CoRe) of the undergraduate professors.

Name				
School degree				
Age				
Teaching experience (years)				
Central ideas	**Spontaneity, reversibility and equilibrium**	**Stoichiometry and reaction progress**	**Thermodynamic properties (S, G)**	**Chemical potential (μ)**
Please answer as fully as possible, for each of these core concepts, the following questions:				
Why it is important for students to know this?				
Difficulties/limitations connected with teaching this idea.				
Difficulties/limitations connected with learning this idea.				
Teaching procedures and didactic methodologies (analogies, metaphors, examples, demonstrations, reformulations, experiments etc.) do you use for student to identify the importance of this central concept?				
Specific ways for ascertaining students' understanding or confusionaround this idea.				

We reduced the eight questions that Loughran suggest to the next five:

1. Why it is important for students to know this idea?
2. Difficulties/limitations connected with teaching this idea.
3. Difficulties/limitations connected with learning this idea.
4. Teaching procedures and didactic methodologies (analogies, metaphors, examples, demonstrations, reformulations, experiments, etc.) do you use for student to identify the importance of this central concept?
5. Specific ways for ascertaining students' understanding or confusion around this idea?

One of the objectives of our research is to observe how teachers propose to teach the thermodynamic parameters for the learning of chemical equilibrium. On that basis, we would modify the designed teaching-learning sequence, and then test it in one of the groups of the participant in the investigation.

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