Progressive evaluation of school science models. An example from the teaching of chemistry.

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ABSTRACT

This research is part of a doctoral training process and seeks to develop a proposal for the progressive evaluation of *School Science Models (SSM)*. This proposal will be carried out for the teaching of stoichiometry, through the implementation of a modeling process with first year high school students in three educational institutions in the province of Concepción, Chile. To develop this research, three teachers who teach their classes through modeling processes will be invited to participate. Consensus will be established with them in relation to the modeling cycle, the progression of MCE and its corresponding evaluation. The objective is to obtain results that contribute to the dialogue and discussion around the evaluation processes present in modeling processes in the didactics of experimental sciences.

Keywords: School science models, modeling cycles, model evaluation.

1. INTRODUCTION

The teaching of chemistry plays a fundamental role in scientific literacy, allowing students to understand chemical phenomena present both in everyday life and in the natural environment [1]. Contextualized understanding of chemistry teaching proves crucial to foster autonomy and metacognition in students [2], representing one of the main challenges in the didactics of experimental sciences, especially in chemistry [3].

In response to this challenge, authors such as Adúriz-Bravo and Izquierdo in 2009 developed a proposal called School Science Model (*SSM*) [4], which has become a line of research that continues to be developed to date [5, 6]. In this line, we are interested in highlighting the proposal of Marzabal et. al. [5], who focus the teaching of chemistry through SSM, defining the *School Chemistry Model (SCM)*, and identify three SCMs present in the school curriculum: *matter model*, *chemical reaction model* and *thermodynamics model*. The importance of the SCMs for the teaching of chemistry is that they allow the identification of the different components present in them through: *conditions*, *entities*, *properties*, *activities*, *organization*, *reasoning* and *facts*.

Until now, the literature has focused mainly on the theoretical discussion of what a model is and what its implications are for science teaching [7], leaving a gap in terms of its evaluation. That is why the contributions of Nelson and Davis [8] and López-Mota and Rodríguez-Pineda [9] stand out as one of the few contributions related to the evaluation of models. These authors propose the idea of a *School Science Model of Arrival (SSMA)*, which identifies the essential components that the teacher expects his students to learn. This proposal is interesting, as it suggests that the initial models proposed by the students could be a "diagnostic assessment", marking the starting point. During the modeling cycle, students are expected to develop the *Model of School Science Achievement (ASSM)*, which could be compared with the vision set by the teacher as a goal before starting the teaching process. Despite being a valuable contribution to the field of experimental science didactics, the proposal is still incipient to address the complex phenomenon of evaluation, so we could ask ourselves *what are the key elements to develop a proposal for progressive evaluation of school science models in the teaching of stoichiometry through a modeling cycle?*

2. CONCEPTUAL FRAMEWORK

To answer the research question, we could establish that the use of models through modeling processes in the teaching of chemistry [10], contribute to a science education closer to the real context in which scientific knowledge is built. In this sense, model-based teaching is one of the topics that have attracted attention for the didactics of experimental sciences and that has attracted a great deal of work in this area during the last thirty years [4]. Oh [10] gathers some ideas from various authors from the philosophy of science, stating that the development of theoretical and experimental scientific knowledge must be accompanied by the construction and testing of models.

It is important to note that, in the context of science education, specifically in the discipline of chemistry and earth sciences, the proposal of scientific models coming from philosophy makes special sense [10]. Both disciplines advance and consolidate to a great extent on the basis of different models, therefore, to teach them in the classroom they are also resorted to quite frequently. Oh [10], mentions in his work that there is quantitative and qualitative evidence on the positive effects of using models in science teaching. It is important then that teachers and also trainers of trainers have valid and solid notions about what a model is, so that they can use them effectively in the classroom through modeling processes. Following this line, Garrido-Espeja and Couso [11] have developed a modeling cycle for teaching science through models, which consists of six stages that start from the need to *recognize a model*, *express a model*, *evaluate the model*, *revise the model*, *express the final model*, and *use the model to predict or explain a new phenomenon*.

In the Latin American scenario, research on models and modeling has also attracted deep attention. For chemistry teaching, the proposal by Marzábal *et. al.* [5], which establishes three SCM that structure the school curriculum, provides teachers with models that allow them to account for the explanations of chemistry phenomena that they must teach in the classroom.

With this background, the key elements present in a progressive SSM evaluation process can be related to the proposals mentioned here [4, 5, 6, 9] (see Figure 1) taken to the classroom

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under Garrido's modeling cycle proposal [11] that has shown to have positive effects in this sense [12].

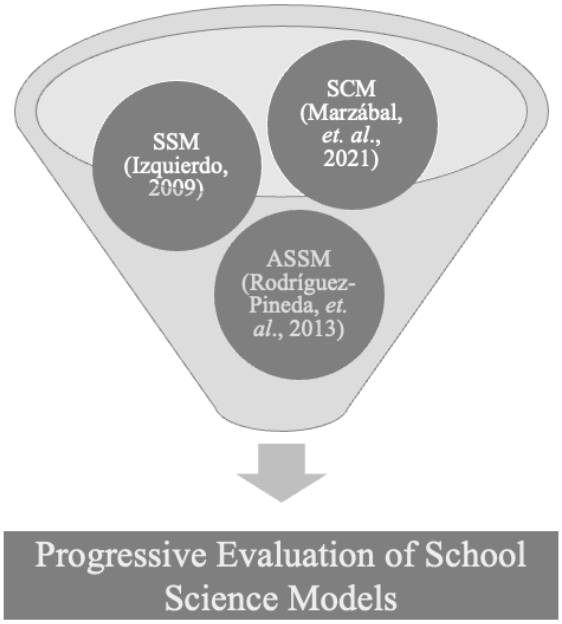

Figure 1. Representative scheme of the topics addressed in the proposal (Prepared by the authors).

3. METHODOLOGY

This study will be conducted from an interpretive paradigm [13] with a qualitative approach through a case study [14]. It seems important to us to consider the proposal of the authors Denzin and Lincoln [13], since they emphasize the importance of understanding reality through the meanings that people assign to it in the construction of knowledge. In this sense, collaboration with the subjects of study to understand their subjective realities and their social contexts to understand the processes that occur in their classrooms, seems very important to us. In addition, it gives the participating subjects a space for collaboration in the project, and not only as subjects reduced to the production of data.

To carry out this research, two phases are proposed (see Figure 2), which comply with the specific and general objectives of this project. *Phase 1* corresponds to the characterization of teaching and evaluation through SSM of the participating teachers, and *phase 2,* to the design and implementation of an evaluative practice through SSM constructed jointly with the participating teachers.

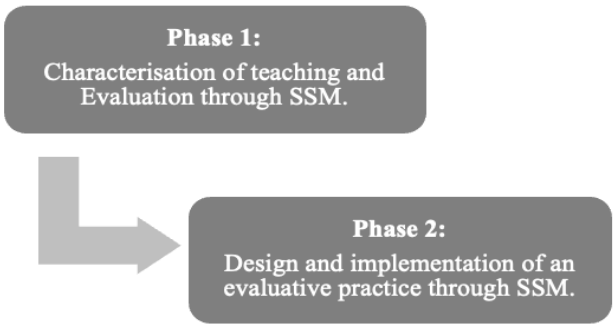

Figure 2. Phases for the methodological design (Prepared by the authors)

In both phases, data collection will be carried out using different data collection techniques, corresponding to *documentary analysis*, *in-depth interview* and *participant observation* [15]. These techniques will allow a deeper understanding of the participating subjects, their way of working, their knowledge about models and modeling processes and the way they bring it to the classroom.

Below is a detailed summary of the phases, including informants, data collection technique, information to be collected, how data analysis will be performed, validation processes, and important ethical issues to consider.

Phase 1: "Characterization of teaching and evaluation through SSM".			
Key informants	**Data collection techniques**	**Information to collect**	**Ethical aspects**
Chemistry teachers	Documentary analysis. In-depth interview.	knowledge of assessment and modeling involved in your practice as a chemistry teacher.	Written informed consent from each study participant.

Phase 2: "Design and implementation of an evaluative practice through SSM".			
Key informants	**Data collection techniques**	**Information to collect**	**Ethical aspects**
Chemistry teachers	Documentary analysis. Participant observation.	School science models designed in the exercise of their teaching process	Written informed consent from each study participant.

Table 1. *Methodological elements of the research (Prepared by the authors)*

The selection of participants will be voluntary through a formal invitation to participate in this project. The inclusion criteria will be to be a practicing chemistry teacher in an educational establishment in the province of Concepción (Chile), and to develop their classes through learning sequences that incorporate modeling processes. The purpose will be to know the meanings that they give to the evaluation in the school modeling process from their subjective realities [13], and to characterize key elements that may be present in the evaluation process of SSM. At this stage, participants will be asked to sign a written informed consent form to confirm that their participation is voluntary.

The data analysis will be carried out jointly by the researchers and the participating teachers. It will be based on three methods, which are: *content analysis*, *analytical* induction, and *triangulation*. Content analysis [15] is a technique of interpretation of written and oral texts, filming, photographic records, interview transcripts, observations, speeches, documents, among others, to consider all the information that the participants can generate. Analytical induction [16], seeks to find those invariable aspects present in all the information obtained regarding their teaching and evaluation processes. This analysis is important, since it will provide us with key elements present in modeling processes. From this information, we will be able to

establish a proposal that includes those basic and essential aspects of evaluation through SSM. Finally, *triangulation* [15] will allow us to contrast visions or approaches of the participating subjects and researchers. This part is important for us, because it considers a joint construction without losing rigor and depth, allowing us to reduce biases in the research.

4. FUTURE PERSPECTIVES

The scope of this study hopes to contribute to the planning and teaching of chemistry through a modeling cycle. It is expected to characterize the key elements present in the progression of SSM through consensual evaluation processes. On the other hand, the limitations of the present study are related to the scarce existing literature on the evaluation of modeling processes in the didactics of experimental sciences [17, 18, 19, 20].

The absence of evaluations present in the modeling processes is a challenge for those teachers who develop their classes through modeling processes. In this sense, there is a risk of using traditional evaluations that consider the final result of the process and not during the process. On the other hand, in the literature there is a polysemy of the term model, which can lead to a plurality of conceptions in the science teachers participating in the study. In this sense, this study warns of the need to identify those notions previous models in teachers [7] which highlights the need for a consensus on the key elements of scientific models and the modeling process.

This project is in an adjustment stage, both in the characterization of the problem and in the methodological aspects and aims to highlight the importance of the evaluation of models in the modeling process for chemistry teaching. With this work, it is expected that future chemistry teachers who develop their classroom practices through modeling processes, can have theoretical elements to evaluate the MCE of their students.

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