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Argumentation in chemistry teacher education: Past, present and future opportunities

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Abstract: This article reports the results of a thesis about argumentation in Colombian chemistry teacher education. Firstly, literature review is discussed in order to determine how research advances in argumentation and science education are involved –or are not- into training Colombian chemistry teacher programs. Secondly, types of questions employed by three pre-service chemistry teachers are analyzed to understand how they provoke –or do not- students' argumentation. Finally, the results of this study permit to suggest a program to educate future chemistry teacher based on how to enrich students' learning through argumentation.

Keywords: Argumentation. Science education. Teacher education. Chemistry teaching.

Introduction

“Students’ argumentation level depends not only on how teacher has been prepared to engage them into the progress of their thinking abilities. Nevertheless, the instructor plays an overriding role” (Archila, 2014a:16). Several studies related to argumentation and science education (Archila, 2014bc; Buty & Plantin, 2008; Erduran & Jiménez-Aleixandre, 2007; Geelan, 2012; Khine, 2012; Muller & Perret-Clermont, 2009; Zohar, 2007) emphasize that science teachers must be prepared about how to promote students’ argumentation. However, in the last two decades only 30% of research has been dedicated to the theme of teacher education and argumentation (Archila, 2012).

To incorporate argumentation as part of the abilities and contents of science teacher training programs, it is imperative to select a theoretical framework connected to the philosophy that represents the professional profile expected (Stipcich et al., 2006). One of the potentialities of argumentation in science education is the opportunity of solving differences of opinion through critical thinking (Osborne et al, 2004; Stipcich et al., 2006).

Furthermore, it is necessary to recognize in science the very common existence of disputes that cause argumentation and debates addressed by Plantin (2004, 2005) and Osborne (2010), who consider these situations as privileged scenarios to construct a point of view and give reasons to support it. In addition, Mortimer and Machado (2001) confirm that consciousness and participation’s students in conflicts solution, depends not only on the selection of appropriate strategies, but also on the discourse constructed around class activities. That is why the role of science teacher is underlying to engage students in manners to learn through argumentation (Archila, 2014a).

“Unfortunately, until recently, very little work has been done specifically about TE [Teacher Education] and PD [Professional Development] in the field of argumentation, perhaps because teaching argumentation has only recently become a widespread and common educational goal. There are therefore only a limited number of sources

that address argumentation in TE and PD programs" (Zohar, 2007:246). Despite the fact argumentation must be an imperative aspect for the professional development; many science teachers do not know the importance of this thinking ability (Simon et al., 2006). That is the one reason why it is important to include it into pre-service teachers training programs. This article is based on the past and present of teacher education in order to suggest some alternatives to prepare future chemistry teachers about how to potentiate students' argumentation.

Argumentation research in the Past

Archila (cited by Adúriz-Bravo, 2014) confirms in research community an increasing interest for studying argumentation in science education. This author surveyed argumentation research on the last two decades following two phases. In the first one, a systematic method of databases search was used. Search was done from 1990 and all languages were taken into account. Archila (2012) found the main publications in major journals of science education (*Ciência & Educação*, *Cultural Study of Science Education*, *Educación Química*, *Enseñanza de las Ciencias*, *International Journal of Science Education*, *Investigações em Ensino de Ciências*, *Journal of Research in Science Teaching*, *Journal of Science, Mathematics and Technology Education*, *Research in Science Education*, *Revista Chilena de Educación Científica*, *Revista Electrónica de Enseñanza de las Ciencias*, *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, *Science Education*, and *Science & Education*), of educational research in general (*British Educational Research Journal*, *Cognitive Development*, *Harvard Educational Review*, *Journal of Applied Developmental Psychology*, *Linguagem, Cultura e Cognição: Reflexões para o Ensino e a Sala de Aula*, *Review of Research in Education*, and *Teaching and Teacher Education*) and of specialized books (*Argumentation and Education*, *Argumentation in Science Education: Perspectives from Classroom-Based Research*, *Argumenter en Classe de Sciences. Du Débat à l'Apprentissage*, *Didáctica de las Ciencias Experimentales*, *Foundations of Argumentative Text Processing*, *Handbook of Research on Science Teaching and Learning*, *Handbook of Research on Teacher Education*, and *International Handbook of Science Education*).

Archila's (2012) study revealed "in the last two decades, less than 30% (see Figure 1) of research has been devoted to preparing future science teachers in how to promote argumentation in the learners" (Archila, 2014a:4).

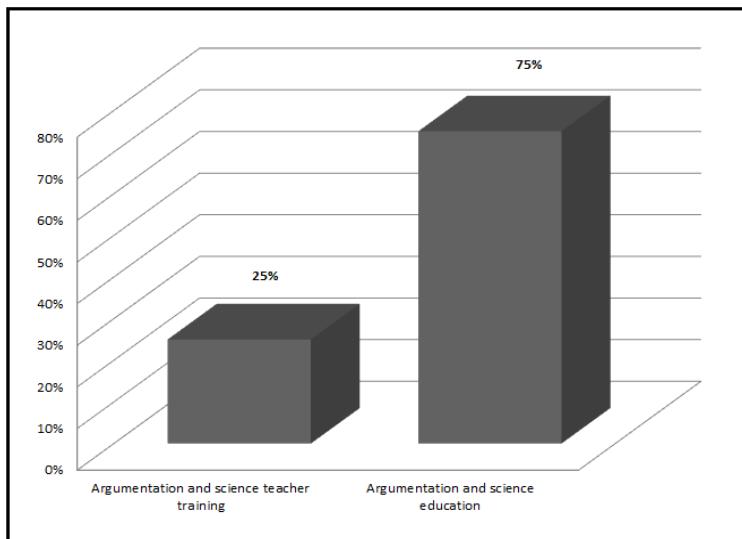


Figure 1. Research on argumentation 1990-2010 (Archila, 2012:368)

Findings showed on Figure 1 demonstrate a clear necessity to continue researching about argumentation and teacher education. These results could be useful to understand why students do not develop argumentation as society expects. In front of this panorama, incorporation of argumentation in teachers training programs must be a priority so as to prepare science teachers capable of enrich students' argumentation through science education.

The present of argumentation in science teacher education: the case of Colombia

To comprise the present of argumentation in science teacher education, this section concerns to the study of practical works (PW) (Hegarty-Hazel, 1990) developed by three Colombian chemistry pre-service teachers' with high school students (see Table 1, real names were changed).

Table 1. Cases selected

CHARACTERISTIC	CASE		
	Víctor	Ángela	Marcelo
Gender	Male	Female	Male
Age	21	24	23
PW content on chemistry	Distillation	Nomenclature	Nomenclature

Archila (2014c:38)

WP of the three pre-service teachers was recorded on video (see Figure 2) and data treatment was done using Transana® (transana.org). Data analysis is focused on type of questions that pre-service teachers ask to students and how those promote – or do not- argumentation (Archila, 2014c; Xie & So, 2012).

**Figure 2.** Place of the video camera during the WP (Archila, 2014c:93)

The analyses of WP are supported on the proposition of Lemke (2012) who states that the language people speak or write may be part of (verbal) research data only when the investigator transposed from the activity in which this language occurs to activity of analysis. Four types of questions were analyzed: open questions, closed questions, rhetorical questions, and managerial questions (McNeill & Pimentel, cited by Archila, 2014c; Xie & So, 2012).

This study reveals a minimum percentage (see Figure 3) of open questions formulated for three pre-service chemistry teachers to students during WP.

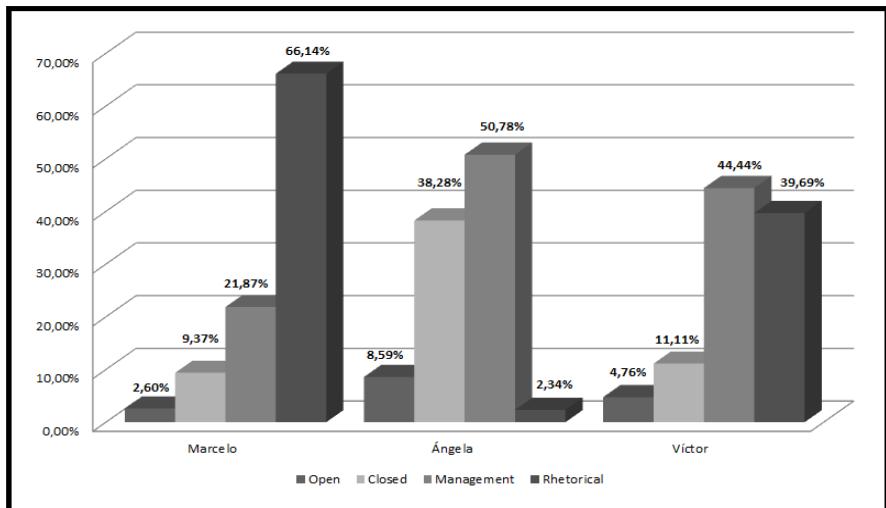


Figure 3. Types of questions formulated by the three cases

The situations question/answer in this research are assumed as key components of argumentative interaction (Plantin, 1998). On top of that, open questions are a potential element to engage students into discussions and patronize argumentation (Archila, 2014abc; Buty y Plantin, 2008; Erduran y Jiménez-Aleixandre, 2007; Khine, 2012; Muller y Perret-Clermont, 2009; Sadler, 2011). Nevertheless, pre-service chemistry teachers spend most of the time on rhetorical questions (Marcelo) and managerial questions (Ángela and Víctor).

WP guidelines designed by the three pre-service teachers were also analyzed to characterize them and to determine type of questions formulated. Characterization done permits to affirm there are important differences (for engaging students' discussion) between those guidelines (see Table 2).

Table 2. Characterization of WP guidelines

CHARACTERISTIC	WP GUIDELINE – MARCELO	WP GUIDELINE – ÁNGELA AND VÍCTOR
Content on chemistry	Distillation	Nomenclature
Title	Distillation	Work in the mine
Objectives	<ul style="list-style-type: none"> To purify a liquid compound by distillation To separate a mixture of two organic liquids by 	<ul style="list-style-type: none"> To analyze the conditions under which a patient (Raúl) has been exposed during his work in the mine (Not explicit)

	fractional distillation •To obtain the essential oil of a vegetable	in the guideline)
Materials	Explicit in the guideline	Not explicit in the guideline
Procedure	Explicit in the guideline	Explicit in the guideline
Lines for elaborating the laboratory report	Explicit in the guideline	Not explicit in the guideline
Guiding questions	Explicit in the guideline	Not explicit in the guideline

Archila (2014c:100)

On the one hand, Marcelo's WP guideline had a *conventional* structure in the type and order that provides information and instructions to students. On the other hand, Ángela and Víctor's WP is more innovated because it suggests a context and allows the WP makes sense for students (Archila, 2014c).

The objectives of Marcelo's WP were related "to purify", "to separate" and "to obtain" (see Table 2), and this relation demonstrates a clear tendency to prioritize contents on chemistry over thinking abilities such as justification, explanation and argumentation. Thus, to enrich students' argumentation through chemistry education, students must have proper opportunities to discuss constructing a stance based on scientific literacy (and others elements) good performed (Archila 2014c; Buty & Plantin, 2008; Díaz de Bustamante & Jiménez-Aleixandre, 2000; Jiménez-Aleixandre & Reigosa, 2006; Schwarz et al., 2008). Added to that, Ángela and Víctor used the verb "to analyze" showing (from the WP design) intentions to farther students' thinking abilities. Nevertheless, none of the three cases routes those objectives to promote students' argumentation (see Figure 3).

Type of questions used in the WP guideline was also analyzed so as to determine if those invite –or do not- students to argue. The questions on Marcelo's guideline are explicit, and on Ángela and Víctor are not. What is important to note though is that results show a low percentage of open questions in the three cases confirming argumentation does not make part of WP designed by three pre-service chemistry teachers (see Figure 4). "Open questions can support students' argumentation in the

science classroom (McNeill & Pimentel, 2010), while few open questions brings little argumentation" (Xie & So, 2012:16).

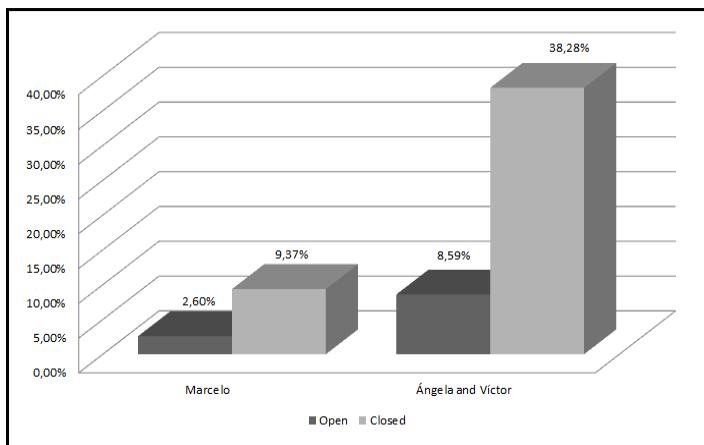


Figure 4. Percentage of questions from WP guidelines

A proposal for training chemistry teachers on argumentation: a view to the future

This study demonstrates a clear necessity to prepare future chemistry teachers on how to perceive argumentation as a thinking ability to be enriched through learning process. This posture demands to think about how those teachers could construct proper methodologies to generate educational processes based on students' argumentation. Conscious of this situation, Archila (2014c) proposed the module "TEACHING AND LEARNING CHEMISTRY THROUGH ARGUMENTATION" (my translation), designed for pre-service chemistry teachers training and that could offer relevant opportunities to involve teachers on argumentation.

There is not enough space in this paper to explore all the ways in which the module could be applied. It is divided into three main instructional components: *theoretical framework, observation of videotape data from work practice and types of chemistry teacher practices* (see Figure 5). That strategy integrates a body of knowledge about history, theories and perspectives of argumentation, this permits future chemistry teachers know the foundations (from language sciences) of this thinking ability. Thus, future educators will have a theoretical support that will help them to analyze videotape data from work practice. Afterwards, based on theory and practice rumination; teachers will be ready to design, to implement and to assess their own

activities and materials they would utilize in their chemistry teaching process to enhance students' argumentation and chemistry comprehension.

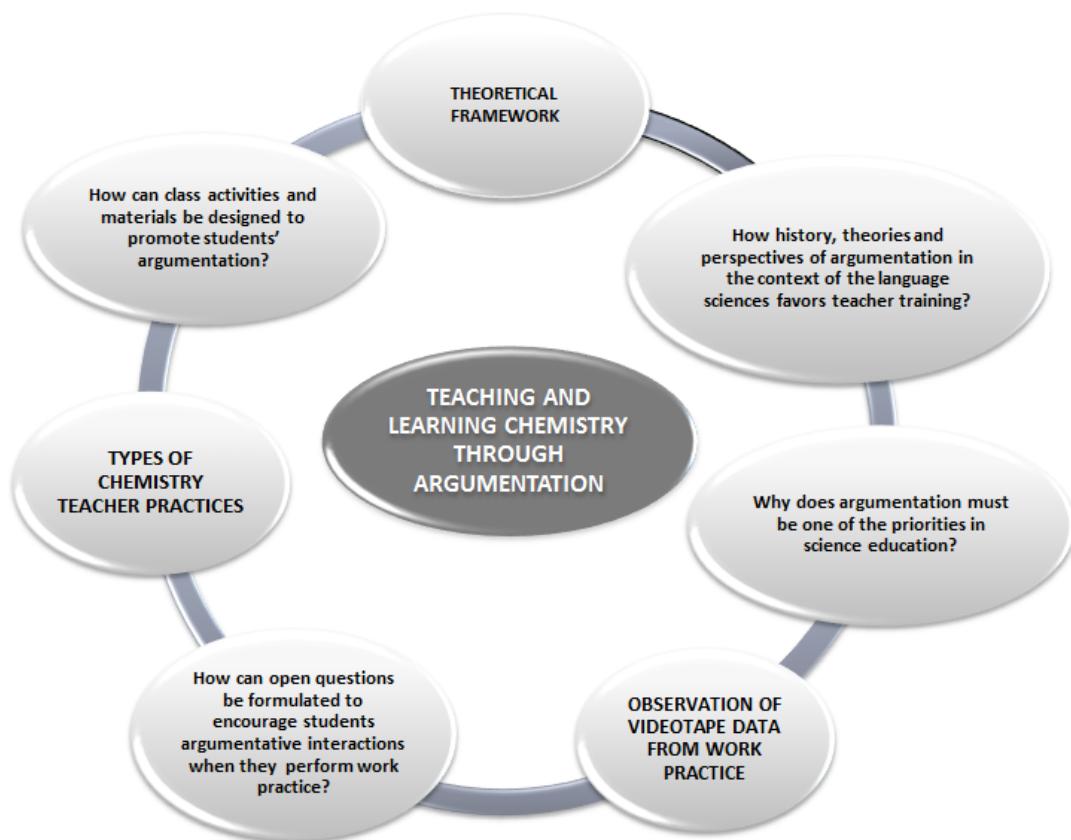


Figure 5. Components of teaching and learning chemistry through argumentation

Final considerations

Argumentation in chemistry teacher education has not been a priority of the research on science education in the last two decades. As result of this situation, future chemistry teachers are not prepared to promote students' argumentation (Archila, 2014c; Jiménez-Aleixandre & Reigosa, 2006; Xie & So 2012).

This view of argumentation in chemistry teacher education suggests that succeeded research must be done in order to understand questions, such as: How can teachers training programs prepare science educators to enhance students' argumentation? How can future chemistry teachers develop suitable class activities and materials to promote critical thinking? and How can learning communities involve pre-service chemistry teachers into proper practices that encourage students' argumentation?

Finally, this research confirms argumentation in chemistry teacher education as a potential chance to enrich students' thinking abilities, leaving in a second place the conventional disciplinary contents. It demands an urgent upgrade teacher training programs so as to contribute with the generation of chemistry teachers capable of leading alternative practices supported on the premise: *teaching and learning chemistry through argumentation*.

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