Methodological conditions for learning biology through writing and arguing: university students' perspectives

Condiciones didácticas para aprender biología escribiendo y argumentando: perspectivas de estudiantes universitarios

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Abstract

During recent years, research has tried to establish the role that argumentation and writing play in learning different disciplines. This attempt has been particularly relevant in the field of Science Education. Therefore, this work presents preliminary results of a research aimed to identify and characterize the methodological conditions for learning Biology by means of arguing and writing at university. This research has been carried out since 2012 in an introductory Biology course belonging to the "Ciclo Básico Común" of the University of Buenos Aires. Focusing on the analysis of interviews, we try to establish how students in one Biology course perceive the activities of argumentation and writing proposed by their professors. In this regard, we find that, in this class, students appreciate five conditions under which writing and arguing would function as epistemic tools for learning Biology. In this vein, the systematic work with writing and arguing help students think differently about the subject and, consequently, this allows them to participate and use the disciplinary concepts in practical matters and real life situations.

Key words: *science education, university, practices of written argumentation.*

Resumen

Durante los últimos años, muchas investigaciones trataron de establecer el papel que juegan la argumentación y la escritura en el aprendizaje de diferentes disciplinas. Este intento ha sido particularmente relevante en el campo de la educación científica. Por lo tanto, este trabajo avanza los primeros resultados de una investigación en curso encaminada a identificar y caracterizar las condiciones didácticas que permiten aprender Biología escribiendo y argumentando en la universidad. Esta investigación se ha realizado desde el año 2012 en un curso introductorio de Biología perteneciente al "Ciclo Básico Común" de la Universidad de Buenos Aires. Focalizando el análisis de entrevistas, tratamos de establecer cómo los estudiantes de este curso de Biología conciben las actividades de argumentación y escritura propuestas por sus profesores. Así, encontramos que, en esta clase, los estudiantes aprecian cinco condiciones didácticas bajo las que escribir y argumentar funcionarían como herramientas epistémicas para aprender Biología. Además, consideramos que este trabajo sistemático con escritura y argumentación ayuda a los estudiantes a pensar de manera diferente los contenidos de la materia y, en consecuencia, esto les permite participar y utilizar los conceptos disciplinares en casos prácticos.

Palabras clave: *educación científica, universidad, prácticas de argumentación escrita.*

INTRODUCTION

During recent years, research has established the role that argumentation and writing play in the learning of different disciplines (e.g. Padilla & Carlino, 2012; Padilla, 2012). In the field of Science Education (Physics, Chemistry, Biology, Oceanography, etc.), for example, argumentation -understood as "the ability of linking data and conclusions and of assessing theoretical statements in the light of empirical data" (Jimenez-Aleixandre & Diaz de Bustamante, 2007, p. 361)- has gained particular relevance, both at secondary and university levels (Buty & Plantin, 2008; Jimenez-Aleixandre & Diaz de Bustamante, 2007, 2008; Jimenez-Aleixandre & Puig, 2010; Kelly & Bazerman, 2003; Orange, Lhoste, & Orange-Ravachol, 2008).

In response to the need for deepening these inquiries, our work takes into account some basic background on argumentation and writing in Natural Sciences, particularly in Biology classes, and focuses on the students' perspectives in this regard. In this sense, students' views from an introductory Biology course belonging to the University of Buenos Aires (UBA) are analyzed.

This article's objectives, then, can be stated as follow: (1) to understand students' perspectives about the practices of argumentation and writing in science classrooms, especially at University and in Biology; and (2) to establish didactic conditions for working with writing and arguing in order to learn appreciated by an Argentine group of Biology students.

This work is framed in the WAC (*Writing Across the Curriculum*) and the WID (*Writing in the Disciplines*) lines of research (Bazerman, 1981, 1988; Carlino, 2005; Emig, 1977; Young & Fulwiler, 1986). These research lines propose that the ways of writing and arguing differ from one discipline to another. Consequently, and particularly at the undergraduate level where students are trying to enter in new discursive communities (Bazerman, 1988; Swales, 1998), professors of each discipline should take care of teaching these disciplinary ways of writing and arguing (Carlino, 2012).

METHODOLOGY

The data presented in this article are part of a wider doctoral research focused on the practices of argumentation and writing in two university disciplines (Biology and Linguistics). This wider research aims to answer the question about which are the didactic conditions for writing and arguing to learn at university. In other words, we wonder under which conditions writing and arguing could be transformed into epistemic tools for learning contents and disciplinary logics at the first year of higher education. In this paper, our case study, an introductory Biology class of the University of Buenos Aires (Argentina), was chosen precisely because their teachers incorporate argumentation and writing in their daily classroom activities. In this sense, we have what Patton (2002) calls *purposeful sampling*, i.e. a case that illustrates some points that are deemed to be relevant (and crucial) in order to think argumentation and writing in science classrooms at university.

Additionally, from a qualitative and interactive approach (Maxwell, 2013), the fieldwork techniques used in this investigation carried out during a semester in 2012, were collection of classroom documents (exams, written assignments, students' notes, etc.), semi-structured interviews with students and teachers, questionnaires and participant observation. Here, we primarily use the views of students about writing and arguing in order to learn Biology in college. It is worth mentioning that these standpoints or perspectives were gathered through 12 semi-structured interviews carried out individually, with an average duration of 20 minutes each. For the analysis of these interviews we used *coding* and *contextualization* (Maxwell & Miller, 2008). Thus, so far, some categories were identified and we could advantageously triangulate them (Maxwell, 2013) with participant observation records and with theoretical approaches.

RESULTS AND DISCUSSION

Regarding the course which is the case study here, Carlino (2012) and De Micheli and Iglesia (2012) state that it provides an unusual illustration of a model of writing interwoven in a Biology course. In this case, teachers not only assign topics from which students must establish relationships with disciplinary contents, but they also invest time for collectively planning and revising the texts produced by students. In effect, teachers give students many opportunities to practice and receive feedback about the kind of writing that then they will be required to produce in the exams (for example, explaining practical situations relating key concepts, using real cases in order to explain and describe processes, etc.).

Carlino (2012) underscores that this kind of experience promotes interactions between teachers and students and among peers, constituting an example of what Dysthe (1996) called *Dialogic teaching strategies*. The notion of *Dialogic teaching* (Bajtin, 2004; Dysthe, 1996) conceives the

classroom as a space that involves multiple voices that need to dialogue in order to generate new meanings. In dialogic teaching, teaching involves integrating speech and writing; it requires teachers to formulate authentic questions and exercises that help students connect their writing tasks and assignments with their personal experiences. The writing is transformed into a key-learning tool. Students, whose voices are appreciated in the classroom, can consider themselves as valid interlocutors within their disciplinary community. Moreover, in our case, in this interwoven model, writing assignments not only help students learn the disciplinary contents but also help them develop the specific practices of reading and writing in Biology as a scientific field of knowledge (Toulmin, 2001). Furthermore, writing and arguing about scientific issues contribute to avoid classes focused only on the teacher's voice and encourage students to play a more active role in their own learning processes. To some extent, these practices of written argumentation undermine the monological classes, in which the teacher stands as the only legitimate voice, and lead the path to dialogue and to the joint construction of knowledge (Duschl & Osborne, 2002).

In this article, we add to the reflections of Carlino (2012) and De Micheli and Iglesia (2012), the idea that the work carried out with argumentation and writing in this course, besides promoting the learning of disciplinary contents, allows students to go into certain disciplinary logics. In this vein, by means of fieldwork, we postulate that in this seminar, beyond this model of disciplinary contents interwoven with writing assignments, teachers introduce students to the ways of *thinking* and *reasoning* in Biology. This form of reasoning inherent to the discipline of Biology involves, first, reasoning in a relational, dialectic, dialogic, process-focused way. It requires, essentially, not to memorize names of enzymes, proteins, systems, etc., but to think of the origins of biological processes and their interrelationships. In addition, it encourages students to do this through the use of concepts and by means of the exercise of argumentation and writing.

Thus, according to the perspectives of the students of the Biology course studied, five didactic conditions allow them to learn Biology developing and employing this kind of disciplinary way of thinking:

1. Writing tasks focused on justifications and relationships between processes

The majority of the interviewed students (11/12) declared that the writing tasks, including activities of justification and active use of disciplinary contents, help them learn to think in Biology. A student, for example, argues:

> *L[1]: Writing in this Biology course is different; because you have to integrate everything, link all the concepts. I mean it's not something repetitive as a response learned by heart for each question, but it's an integration of content, so to speak. Everything has a purpose. It's as if you understand that you have to give reasons because there is a reason to do it, not only because they ask you to do that in order to check if you know or not, am I being clear? (…) You have to keep in mind all that when you write here in Biology: why you are writing, for whom, and for what.*

These writing assignments with tasks of justification and relationships are then modeled by rhetorical concerns about why, with what purposes and for whom one is writing. Students reflect on the organization of their activity and their communicative goals (Bazerman, 1981, 1988; Swales, 1998), while learning the disciplinary contents (Britton, 1975; Chain & Hilgers, 2000; Emig, 1977; MacDonald & Cooper, 1992; Prain & Hand, 1999; Rivard & Straw, 2000; Walvoord & McCarthy, 1990; Young & Fulwiler, 1986). Even those students, who -for different reasons- have not written during the entire semester, support *a priori* the opinion that this kind of writing assignments and tasks are useful when it comes to learn disciplinary contents and their underlying logics.

> *A: I, eh [hesitation], particularly have not written many texts because I don't have the time… because I work and I come here, and it's all 100% my time. So I don't do them, but it seems to me that they are very positive because they help my classmates. These texts make them improve, that's for sure. I don't know, I think writing could help me too [laughs]. These texts and the comments the teachers give point you out what parts or concepts you have to reinforce. And that I think is extremely good.*

These writing assignments, then, propose students not only to articulate and relate what they are learning with their own personal experiences, but also to exercise a different way of thinking. These tasks are one of the keys to developing a biological thinking, since they allow students to take advantage of the epistemic potentials of writing and arguing (Carlino, 2005, 2012; Leitão, 2000). In this sense, these writing assignments are closely linked with other didactic condition that enables the development, improvement and employ of this particular way of thinking to learn Biology: participation and use of concepts.

2. Participation and use of the concepts

Bisault (2008) underlines that, in science classes, it is not a matter of thinking how we could materialize the characteristics of scientific reasoning, but how we analyze and implement our daily scholar practices in reference to the social practices of researchers, the real producers of scientific knowledge. In the same vein, Rebière et al. (2008) also considered advantageous to carry out a parallel between the activities of the professional scientists and those deployed within the class.

Indeed, this emphasis on the use and appropriation of concepts stands as one of the fundamental pillars of the didactic initiative in the Biology course studied. And that is how students (10/12) perceive it:

> *N: The key is to write because it is in that process where you realize if you have understood the lesson. If you can use the concepts and explain the processes, it is because you know and own them.*

Another student explores the underlying purposes to this use and appropriation of concepts:

> *J: Biology is different, because you write in the assignments and in the exams with a purpose. You should never throw up what you have studied by heart. They always give you a case study, some issue concerning real life, and from there you have to think about what you have studied. You can't memorize, not at all! Because if you don't know how to apply the contents studied or how to think in this case they give you, that's all, you fail. I think it's really interesting. For example, now after studying digestion I understand everything that is happening when I eat, and that's awesome! I can't explain it, what it feels to really know something, you know? In addition, I'm going to study veterinary medicine and this helps me a lot, because it makes me understand that all living beings have points in common. This Biology course gives me the tools to explain that.*

In relation to the use and appropriation of concepts, it becomes relevant the notion of *epistemic practices.* This notion, coined by Kelly and Duschul (2002) and used by Jiménez Aleixandre and Diaz de Bustamante (2008), conceives the *epistemic practices* as a set of activities associated with the production, communication and evaluation of knowledge. In this case, Biology students, through these practices of writing and arguing, must not only produce knowledge from specific cases, but also exercise the epistemic practices of articulating their own knowledge with the knowledge of others. The recognition of the epistemic dimensions of argumentation and writing lies in this use and appropriation of concepts through the practices of writing and arguing. These epistemic dimensions are understood by Leitão (2000) as the confrontation with the knowledge of others that requires to review our own knowledge.

In addition, this involvement and this use of concepts in Biology, as Kuhn (1991) suggests, can only be acquired through practice. Indeed, writing and arguing promote learning in science classroom as long as students have the opportunity to discuss explicitly contents and concepts, by means of meaningful activities and constant teachers' feedback. In the Biology course studied, teachers underpin the essential features to develop the students' scientific thinking: coordinating multiple causal influences, understanding epistemological positions and developing the ability to engage students with the contents and with the learning process itself (Kuhn, Iordanau, Pease, & Wirkala, 2008).

3. On-time feedback (frequent and before exams)

Buty and Plantin (2008) ensure that argumentation and writing, thrown in the science classroom without being integrated with the disciplinary contents, entail no epistemic potentials. Arguing and writing only help students learn when certain classroom conditions are generated, granted and guaranteed. "On-time Feedback" constitute one of these didactic conditions, since it allows Biology students to corroborate the assumptions they have made during the study of the subjects, to incorporate their teachers' suggestions in subsequent writings, to correct misconceptions, to rethink hierarchies and causality *in* and *between* processes, etc. However, the most important thing at this point, perhaps, is that this feedback precisely helps students learn because it is made "on-time", i. e. before exams, and not later, when -for the students- it would have been too late. In fact, several students

(11/12) refer to the "on-time feedback" as major criterion when it comes to think and learn Biology.

Interviewer: Your exam was very well! Do you think there is a reason for your success?

T: Yes, I got an A, I can't believe it yet [laughs]. I think I did well because I basically follow the classes every day, continuity, I write and that's important. For example, in the exam when I had written assignments similar to those we have here everyday, it was easy. It is as if you could do that automatically, as you already have the structure in your head. You can relate concepts. I think that it is a straightforward consequence of having exercised that structure, that way of thinking, when I write in this course. Another important thing is that teachers comment your pieces of writing on time, I mean, the same class or the next class, and that helps you think class to class and to learn how to incorporate the subjects. They point you out what you did wrong and what you did well. Teachers guide you in every text. Well, they are consistent and constant, basically. And we, as students, have to be constant too, above all.

Furthermore, for learning by means of arguing, Buty and Plantin (2008) affirm that students need not only sufficient knowledge about conceptual and practical issues but also about argumentative methods in order to argue in a legitimate, autonomous and not manipulated way. However, acquiring such knowledge and methods takes time. In this regard, the on-time feedback gave by the teachers in our case study understands the complexity of this learning process and tries to deal with it. And that is reflected in students' standpoints. This early, frequent, oral and written feedback (before the exams) promotes, from students' perspectives, the dialogue between teachers and students as well as among peers. This feedback allows the exchange of points of view and the co-construction of knowledge in the classroom.

4. Teacher's interventions oriented to constant maieutic (during class and in written feedback)

Maieutics is the well-known technique that involves questioning a person in order to make him reach knowledge through his own conclusions and not as mere transmission of knowledge learned and preconceptualized. In the Biology course that constitutes our case study, maieutics seems to be a key teaching tool when it comes to support students' learning processes. Indeed, the students (11/12) acknowledge this:

Interviewer: what other things that your teachers do, as well as the texts, do you think that they help you learn Biology? I mean in the dynamics of the class.

C: I find the pictures and graphics in the keyboard very helpful. The last class they draw a giant scheme relating several things. Furthermore, they always ask us if we have questions. And each question we pose, they don't answer it punctual, precisely. Instead, they return you the problem with another question or they contextualize your question in a real case, in an example. That's something awesome. I have never experienced something like that in a class.

In this course, conducted within a didactic intervention based both on immersion and on reflection of socio-scientific issues (Cavagnetto, 2010), maieutics is constant. In fact, argumentation and writing as ways of reflection are used as integrated components into the everyday activities and tasks of the students. Teachers, in the brousseaunian sense of the term (Brousseau, 2007), return the problem to the students and face them with their own questions. Professors, in the first instance, do not "institutionalized" (Brousseau, 2007), but they regulate and guide students through questions about rationale. In this context, students can find themselves the answers to their own questions. In this sense, the contextualization and provision of aims and objectives to the arguments not only allow students to assume, reflect and discuss their very own doubts and certainties, but also allow them to reconstruct the biological knowledge through their own conclusions.

5. *Clinical* (next to the student) and graphic explanations (use of models, magnetic chalkboards and generous use of analogies)

We use the adjective "clinical" here in its etymological sense. From the Greek κλινικός (κλίνη, bedding), originally the word referred to the person who accompanied and cared for the sick alongside the bed. Then, the term served to name the doctor who diagnoses from the foot of the patient's bed. In this paper, we refer to "clinical explanations" as those in which teachers accompany constantly students in their learning processes. We do not return to the second meaning of this word, which refers to the doctor who diagnoses, since we believe that that there is nothing to diagnose in the classroom. In classroom, students only need to be accompanied, guided and steadily helped by their teachers.

Finally, in this Biology course, students (12/12) positively value personalized explanations of their teachers during class. They also appreciate that these explanations are oral and written. A student, consulted about why she believes the she has obtained good mark in one of the tests, responds:

L: I think that, well, first because I studied, but the following work that the teachers made on each of us is wonderful. They [the teachers] take into account all our activities and texts. The class is always oriented, guided by the teacher, but for us. I like that.

Moreover, in addition to these clinic explanations, another highly appreciated feature of these classes highlighted by the students is the use of graphics, models, magnetic chalkboards and analogies.

T: I think that, apart from writing, the pictures that the teachers show on the chalkboard are very graphic and help me understand what they are explaining. Looking at the pictures, one can understand the processes. They serve as diagrams pictures. And then I find useful what they do with the models and slates, I do not know how to call them, because it is more visual, something that it's not so easy to graph mentally, what happens with the nucleotide in the cell, for example. One sees it as something more concrete, less abstract, when we have the models. All these examples and models applied in cases of daily life, Biology becomes interesting [laughs].

Concretize what otherwise would be impossible to see seems to be the cornerstone of the teachers' educational interventions for this course. Students positively valued the efforts of their professors relating to this point. It is not trivial that this theme is recurrent in all the interviews conducted.

In sum, in this Biology course of the University of Buenos Aires, the five didactic conditions set forth in this section configure the classroom space. Above all, they enable students not only to work with writing and arguing to learn contents, but also to develop a different way of reasoning..

CONCLUSIONS

In the introduction of this paper, we have presented two objectives: (1) to understand students' perspectives about the practices of argumentation and writing in science classrooms, especially at University and in Biology; and (2) to establish the didactic conditions for working with writing and arguing to learn appreciated by an Argentine group of Biology students. Regarding the first objective, we have found out that Biology students value positively the opportunity to learn through writing and arguing. In fact, they assure that this kind of written tasks not only helps them learn the disciplinary contents, but also enables them to think *biologically*, i.e. in a relational, dialogic, dialectic and process-focused way. In connection with the second objective, we have stated that a group of Biology students from the university of Buenos Aires appreciates five didactic conditions for learning by means of writing and arguing: (1) writing tasks focused on justifications and relationships between processes; (2) participation and use of the concepts; (3) on-time feedback (frequent and before exams); (4) interventions oriented to constant maieutic (during the classes and by means of written feedback); (5) clinical (next to the students) and graphic explanations (use of models, magnetic chalkboards, analogies, etc.).

In sum, this paper contributes to rethink the role that argumentation and arguing could play in university science classrooms. Students appreciate to be treated as legitimate interlocutors and they want to (re)discover and (re) construct the contents they are learning. In this process of (re)discovery and (re)construction of the disciplinary contents, teachers' interventions seem to be vital. They configure and create the didactic conditions necessary to learn through writing and arguing.

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A step-based learning methodology applied to veterinary science students in biochemistry classes

Una metodología de enseñanza basada en pasos y aplicada a estudiantes de ciencias veterinarias en clases de bioquímica

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Abstract

In an attempt to improve engagement and performance of first year veterinary science students in biochemistry issues, we applied a teaching strategy as follows: the subject was separated into four steps breaking down each one of the topics. Each step was a prerequisite for the next one and at the end of a step, the students had to answer questions and discuss the studied step enabling them to go on to the next step or review. In this way, knowledge was built throughout the classes and both students and the professor were able to point out some misunderstandings, knowledge deficiencies, and pedagogic problems, solving these class issues more effectively. In the work, we focused on studying Enzymes, an interdisciplinary subject that involves thermodynamic and kinetic concepts applied to a biological context. According to the students, they were able to define their learning deficiencies more specifically and become more committed to the class. Additionally, this teaching strategy was clearly effective in maximizing the progress of students.

Key words: *biochemistry, teaching methodology, veterinary science students*