A model for teaching argumentation in science class

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Abstract

Argumentation in science is a dialogic process and a fundamental tool for the co-construction of more meaningful understandings of the concepts discussed in class. Therefore, it is one of the responsibilities to be assumed explicitly in science teaching and learning. The central aim of our research is to propose a model for teaching argumentation in science. We have collected and analyzed qualitatively information from a teacher who participates in a critical reflection process on argumentation and her own performance. The findings evidence how important it is for teachers to deepen their knowledge of epistemological, conceptual and teaching aspects, which are key to a model for teaching argumentation in science. Similarly, we show how identifying these aspects both in the teacher's thought and performance, and the relationship between them, allows constructing a model for teaching science argumentation.

Keywords

Argumentation in science – Teaching models – Teachers' thought – Teachers' performance.

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La argumentación en clase de ciencias, un modelo para su enseñanza[I]

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Resumen

La argumentación en ciencias es un proceso dialógico y una herramienta fundamental para la co-construcción de comprensiones más significativas de los conceptos abordados en el aula. Por ello, es una de las competencias que debe asumirse de manera explícita en los procesos de enseñanza y aprendizaje de las ciencias. El objetivo central de nuestra investigación es proponer un modelo de enseñanza de la argumentación en ciencias. La información recogida para nuestro propósito y analizada bajo el enfoque cualitativo, se obtiene del proceso realizado por una docente que participa en un proceso de reflexión crítica sobre la argumentación y su propio desempeño. Los resultados resaltan la importancia que tiene para el docente profundizar en tres aspectos centrales de un modelo de enseñanza de la argumentación en ciencias: el epistemológico, el conceptual y el didáctico. De igual manera, se muestra cómo la identificación de estos aspectos tanto en el pensamiento como en el desempeño de la docente y su relación, permite construir un modelo para la enseñanza de la argumentación en ciencias.

Palabras clave

Argumentación en ciencias – Modelos de enseñanza – Pensamiento docente – Desempeño docente.

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Introduction

Teaching and learning science is a dialogic process that occurs between teachers and students, and is immersed in specific and complex contexts. This invites reflection on how to turn science lessons into an environment that gives relevance to the subjects not only using their life stories, mental models and interests, but also their ways of communicating and constructing science in class; from Mockus' (2012) perspective, it also invites giving relevance to the intensive use of languages or new communication modes. In other words, promoting debates and discussions in small groups is an effective means not only to achieve the co-construction of collective and more meaningful understandings, but also to facilitate the construction of meaning of the concepts and thereby consciously transfer them to contexts outside the class.

In this sense, this article aims, from a theoretical reflection, to evidence the relevance of language, particularly argumentation in science teaching and learning and, secondly, to propose a model for teaching argumentation in science. The model has been constructed from the relationships identified in the following dimensions: thought and performance of a teacher[1] who participated in a process of critical reflection on teaching argumentation. Relations have been established between three components that we think characterize the models for teaching argumentation: (i) the epistemological component refers to the teacher's view of the place of argumentation in the construction of science; (ii) the conceptual one is related to the teacher's conception of scientific argumentation, and, (iii) the didactic one concerns how she thinks argumentation should be encouraged in science class and what her actions in class to achieve that objective are. Below we shall discuss the importance of argumentation for science teaching and learning, and then address argumentation in science class.

1- Due to space limitations, we shall present the analysis of one teacher only, but the proposed model has been built from the data identified in the five teachers participating in the process of critical reflection.

Language is key to constructing and communicating science

Several authors (BAKER, 2009; BRAVO; PUIG; JIMÉNEZ-ALEIXANDRE, 2009; CAZDEN, 1991; HENAO; STIPCICH, 2008; LARRAIN, 2007; SCHWARZ, 2009; SUTTON, 2003) have noted the key role of language not only in the construction of science, but also in its communication through teaching and undoubtedly in the learning process. In this line of thought, we can say that by using language subjects give meaning to facts, contrast and reach consensus on scientific explanations (IZQUIERDO; SANMARTÍ, 2000).

Teaching and learning as a social action requires improving processes of communicative interaction (HENAO; STIPCICH, 2008), processes in which the development of argumentation, both in school curricula and in their implementation in class, is a priority to achieve deep learning of the topics studied (CHIN; BROWN, 2003). Conceiving science teaching from a discursive perspective allows, on the one hand, making explicit the language used by scientists and adapting its uses and interpretations to different contexts of application. On the other hand, it gives students tools for understanding the work of scientists and the thematic patterns of scientific knowledge and also enables the construction of conscious and deliberate processes, mediated by the uses of language, according to the understanding of phenomena (SUTTON, 2003).

In line with the previous thought, Schwarz (2009) proposes that school efforts should be directed towards designing contexts of argumentation and towards proposing dialogic environments in which students are involved not only by recognizing their personal objectives, but also by identifying objectives and targets of all participants in communicative interactions.

In short, we assume that promoting argumentation practices in class entails recognizing that argumentation is a social activity. This activity promotes students' qualified use of languages, the development of their cognitive, social and emotional skills, the understanding of the concepts and theories studied, and the development of critical human beings, who are able to make decisions as citizens (SARDÀ; SANMARTÍ, 2000).

Models for teaching argumentation in science

Not until recently has relevance been given to the explicit teaching of argumentation in class (ERDURAN; SIMON; OSBORNE, 2004; JIMENEZ-ALEIXANDRE; BUGALLO; DUSCHL, 2000; KAYA; ERDURAN; CETIN, 2012; SAMPSON; GROOMS, 2009; ZOHAR; NEMET, 2012). It is precisely this area that we want to emphasize, trying to bring significant aspects to propose a model to help answer the following question: *how can we promote argumentative processes in science lessons*? In this regard, we know that, in the field of science teaching and learning, to discuss the teaching model is to refer to the concrete proposal that the teacher develops in class aiming at specific educational goals.

Research in the field of modeling teacher practice in class highlights the link between what teachers think and their performance in the processes of lesson planning and practice (CZERNIAK; LUMPE; HANEY, 1999; CLARK; PETERSON, 1986; CHAN, 2004; GIL; RICO, 2003; HANCOCK; GALLARD, 2004). As for the modeling of argumentative processes in science lessons, it is thus essential to understand the relationship between the two dimensions above: teacher thought and performance in class.

Given the above, the work done and presented in this article has aimed to propose a model for teaching argumentation in science class supported by relations between the epistemological, conceptual and didactic aspects, which we think characterize a model for teaching argumentation for the reasons described below.

In regard to the *epistemological* aspect, considering that argumentation is one of the competencies to be developed in science class requires, among other things, an epistemological perspective that values criticism and argumentation as essential actions to construct both scientific knowledge and school science (DRIVER; NEWTON; OSBORNE, 2000; ERDURAN; ARDAC; YAKMACI-GUZEL, 2006). Similarly, argumentation is an action that facilitates the explanation of the internal representations that students have of the phenomena studied, the learning of scientific principles. It also enhances the understanding of the cognitive activity of the subjects when constructing science.

As for the conceptual aspect, we can say that developing argumentative processes in class requires, among other things, accepting argumentation as: a) a dialogic process in which debate, criticism, decision-making, listening and respect for one's own knowledge and for that of the others become relevant; b) a process that promotes student ability to understandably justify the relationship between data and statements; and, c) a process that promotes the ability to propose criteria to help assess the explanations and views of the subjects involved in the discussions. This conceptualization encourages establishing discussion groups in class (MERCER, 2001; OSBORNE, 2012) to work on content that serves as a pretext for students to externalize their argumentative reasoning and thereby show that, in class, science can be co-constructed (FENSHAM, 2004; 2005; LEWIS; LEACH, 2006).

Finally, in relation to the didactic aspect, it should be recognized that the construction of school science demands talking about it, and here, language is the vehicle that allows exchanging meanings, reaching consensus, explaining or clarifying concerns (OSBORNE; SIMON; COLLINS, 2003; SCOTT; MORTIMER; AGUIAR, 2006; WOLFE; ALEXANDER, 2008). These are dialogic processes which transform the monologic, authoritative action of teachers into an action that mediates and promotes appropriate spaces for inquiry and group discussions. In them, one is allowed to expose views, criticize them, and possibly reach consensuses that foster constructing more meaningful and understandable conclusions on the phenomena and topics under study.

Research objective

To propose a model for teaching argumentation in science class that considers the relationships between epistemological, conceptual and didactic aspects.

Method

Research context

Five primary-school teachers participated in the research, which was developed in a public institution in Manizales city, Colombia. As stated above, due to space limitations and aiming at offering a comprehensive overview of analysis and findings, we shall discuss the model for teaching argumentation of only one of the teachers.

Some characteristics of this teacher and the group in which she directs her classes are:

- She has taught science for 19 years.
- This is the first time she has participated in a process of discussion on argumentation in science and its implications for teaching.
- Students are aged 9 to 10 years and come from low socioeconomic levels.
- The group consists of 29 students, who are not used to participating in group discussions due the traditional nature of classes.

Intervention process and data collection

Two global activities allowed gathering information to achieve the research objective.

First, the application of questionnaires and interviews. A questionnaire with six open-ended questions was applied at the beginning and end of the process. The first application was before critical reflection meetings started and the second was seven months later, after all scheduled meetings had been conducted. Upon completion of the second and third classes, we conducted two semi-structured interviews with the teacher, which were recorded on audio and video and whose axis of discussion were the aims of teaching, identification of argumentative processes in recorded classes, evaluative activities undertaken by teachers and the limitations and potential of the process.

Second, the development of critical reflection meetings (CRM) and the recording of classes. We conducted three CRM designed from the recognition that teaching practice is a place of knowledge production, a place where each teacher works as an agent of change and intervention in the education of students. Therefore, teachers were invited to consolidate a culture of collaboration (HARGREAVES, 2005) or a learning community that, in addition to sharing teaching experience, allows them to give sense and meaning to this experience and enrich it with individual understandings (NIELSEN, 2012) to transform their own school reality. Finally, concerning the recording of the classes, we collected and analyzed three lesson plans. The execution of each class was recorded on audio and video. The first class lasted 120 minutes and was taught before the process of critical reflection. The second class was taught after the first CRM and lasted 90 minutes. The third class was taught after the second CRM and also lasted 90 minutes.

Information analysis

Comprehensive descriptive analysis was done in four stages of the process and relied specifically on the analysis of the teacher's oral discourse (classes, interviews, and CRM) and written discourse (plans and questionnaires). The construction of the categories obtained from data analysis was performed in two complementary ways. The first was *inductive* and corresponds to the construction, naming, and description of the categories that emerged from the recorded information from three sources of information: the questionnaire, plans and audio and video records (classes, CRM, and interviews). In the process, we identified words or phrases with meaning, in the data, in order to gradually configure a concrete name or coding, which was then converted, according to the relevance and frequency of occurrence, into families that were useful to make graphs and establish relationships. The second way, which complements the previous one, occurred with the implementation of a *deductive* process; that is, by the use and application of theoretical frameworks for the components analyzed. When possible, relationships were established between data and theoretical assumptions presented in different studies in this field.

From this perspective, these three aspects were examined, as follows:

• We analyzed the epistemological aspect in the teacher's thought from the perspective of how the teacher presents the relation between argumentation and science. Such relation was identified in oral and written texts produced by the teacher in questionnaires, interviews and critical reflection meetings. In classroom practice (performance), to study the epistemological aspect, we verified whether argumentation was one of the objectives of the teacher's lesson plans.

• The conceptual aspect was studied in the teacher's thought considering the meaning given by the teacher, in questionnaires, interviews, and critical reflection meetings, to argumentation in her science classes. And in classroom practice, from the analysis of the type of content that the teacher planned to teach in her classes.

• The didactic aspect in the teacher's thought was studied from the explicit expression in questionnaires, interviews, and critical reflection meetings, of the type of activities and criteria that should be taken into account to enhance argumentation. In her practice, we analyzed the type of questions the teacher asked to achieve argumentative processes in class.

Analysis of results

As stated in the previous section, the data were obtained from several sources: questionnaires, interviews, classes, lesson plans, and critical reflection meetings. Find below an example of the analysis of some of the data identified in the teacher's thought and performance.

• Analysis of the epistemological aspect identified in the teacher's thought, examining an answer to the questionnaire, which allowed learning the relation established by the teacher between argumentation and science at the beginning and at the end of the process.

Diet plays a major role in the etiology and prevention of cancer.

Research from various sources provides strong evidence that vegetables, fruits, whole grains, dietary fiber, certain micronutrients, some fatty acids, and physical activity protect against some cancers.

Two of the possible paths taken to reach these conclusions have been:

• Scientists' direct and objective observation of and experimentation with the phenomenon (cancer and its relation with food).

• Negotiation between the members of scientific communities, in which they presented, discussed, and validated the evidence and conclusions of the observations and experiments.

Considering the above, do you think that the two processes are equally important for the construction of science? Give reasons for your answer.

Fragment of the questionnaire developed for this research.

Find below the answers given by the teacher in the initial and final questionnaire:

Text 1 (initial): Both processes are important for the construction of science because in the process of science teaching there should be experimentation, observation, comparison, analysis, understanding, and dialogue with other people doing the same experiment and research and thus draw some conclusions.

Text 2 (final): I think that both processes are equally important for the construction of science... so we can generate, present, discuss, and validate hypotheses (and draw). To draw conclusions, it is first necessary to observe and experiment objectively and directly... Then socialize with other scientists to discuss, validate the evidence obtained and with them expand, share, discuss these experiments and conclusions, and draw others.

Fragment of the answer given by one of the teachers.

Note that, although the teacher gave importance to negotiation, observation, and experimentation in both answers, in the second one, she incorporated more clear and powerful elements for establishing the relationship between argumentation and the construction of science. In this answer, the teacher recognizes that communicative interaction between subjects leads to constructing, validating or expanding conclusions. Such perspective is in line with approaches that value communication processes and, in them, argumentation as a necessary action for the construction and progress of scientific theories.

The epistemic aspect identified in the teacher's performance, obtained by analyzing the objectives of her lesson plans, evidences that not until the third class did she explicitly propose argumentation as a competence to develop in class.

Table 1. Goals proposed by the teacher in her lesson plans

Plan	Goals
First	To explain the concept of matter. To differentiate between general and specific properties of matter. To state the concept of matter and establish its general and specific properties. To identify common characteristics of all bodies. To differentiate and explain the states of matter.
Second	To compare different kinds of energy that we continually use at home. To identify different energy sources. To explain the different heat sources and their application. To value the proper use of combustion to meet man's needs.
Third	To orally express argued answers to questions. To describe and explain the use of sound in some devices, which are used properly. To explain how sound propagates.

Source: Authors' construction.

In Table 1, it can be further noted that the purposes in the first plan are oriented to declarative content unrelated to issues that may concern student daily life. In the second lesson plan, while argumentation is still absent, the intentions have elements of contextual and evaluative nature. In the third plan, argumentation as a competence to be developed arises at this point in the process, which makes this plan significantly different from the two previous two ones. In this goal, there are two remarkable elements. First, the intention to develop argumentative competences is not subjected to or conditioned by conceptual references, which are of course necessary to achieve such purpose, but what matters is the specific action regardless of declarative content. Second, in this intention, the teacher regards questions as an important mechanism for the development of argumentation.

• Analysis of the conceptual aspect identified in the teacher's thought, examining an answer to the questionnaire. Find below the wording of the question.

If you were invited to speak at an event on argumentation in science class, how would you explain what argumentation in science class requires?

Fragment of the questionnaire developed for this research.

Find below the concept given by the teacher in the two times the questionnaire was applied.

The two answers given by the teacher were:

Text 1 (Initial): The explanation that I would give of what it is to argue in science class is: argumentation in science involves deducting, making things clear, testing, demonstrating, explaining to the others; using plain, easy language to achieve good communication.

Text 2 (final): Arguing in science class is to express what they understand from their own everyday life, to refute concepts if necessary, to say the reason for things, and explain creating a socialization environment in which people can discuss.

Fragment of the answer given by one of the teachers.

In the first text, the concept of argumentation highlights structural elements (tests) from the demonstration processes. In the second answer, the teacher mentions at least four important elements of her conception. The first element is recognizing that student context matters for argumentation. The second is the dialogic interaction between people, an interaction that is based on actions of refutation of knowledge. The third element is the presentation of concepts and viewpoints, a necessary step to construct the content of the discussions. The fourth and final aspect is to create suitable environments in which one can discuss, a task for teachers and students, because it is necessary not only to provide room for discussion, but also to promote and express attitudes of respect and listening to the other.

However, the analysis to determine performance, from recordings the made in the classroom, on the kind of science that the teacher brings to class shows the following:

Table 2. Fragments of class in which the teacher exposes the kind of science that circulates in class.

Fragment of class 1	Fragment of class 3
1:40 T1: let's see, let's see, wait, let's begin to explain using the work guide	1:105 As: *[no, they decompose between 80 and 90 years it is a century
1:41 Sa(1): here it says here there are several pictures with materials with matter, then for example here is a wooden table that is arti this is artificial material because the wood comes from the wood of trees	1:106 Ma: *[you brought information that it was 80, they said it was 500 and you that it was a century, we will find more, we will find more, or it depends, you may all be right, let's see what is your opinion? **¿why may the answer 500 be right, and also the answer 100 and the answer 80?, let's see, why?**
1:42 T1: And what is the wood that comes from trees?	1:107 Aa: it is a century
1:43 Ss: natural	1:108 Ma: let's see Tomás
1:44 T1: **what kingdom?**	1:109 Ao: it is a century
1:45 Sa(1): **what kingdom?**	1:110 Ma: and they said 500
1:46 So(x): plant kingdom	1:111 Aa: *it is a century
1:47 T1: fine ((then the student who is speaking in front asks two of her classmates to go on reading the answers, but no one accepts and she decides to continue exposing the work))	1:112 Ma: **What's going on?** There must be something, **what can you say about why some say a century, some say 500?, why?**
1:48 Sa(1): a notebook a notebook can also be artificial or natural	1:113 Ao: ** because some are bigger than others (…)
1:49 T1: it is artificial	1:114 Ma: ** well, that could be a reason, what else?
1:50 Sa(1): **artificial?**	
1:51 T1: yes	

Authors' construction.

In the fragment of class 1, we observed characteristics of a dogmatic science, a science that does not accept discussions and that requires single true answers. Although the dialogue clearly intends to promote the participation of students and to consider their ideas, this fragment ends up being an interaction that, through convergent or descriptive questions (what kingdom? Or whether the notebook is artificial or |natural|[AC1], in bold), seeks only single answers which do not allow questioning. In the fragment of class 3, the teacher tries to co-construct by dialogic interactions the knowledge that is the basis of dialogue. Here students are invited to present their knowledge, contrast it and try to draw conclusions from their discussions. Note that the development of argumentation is based on the use of evaluative questions or phrases such as: what is your opinion? or, they said 500; and causal questions or phrases such as: why may the answer 500 be right, and also the answer 100 and the answer 80?, let's see, why?, What's going on?, what else? With these questions, the teacher creates an environment suited for inviting students to value and present evidence, and most likely to adhere to or refute the information presented by one of the groups. This is an example of how the teacher tries to bring school science and students closer and of how she intends to discuss it and co-construct it in class.

- Analysis of the didactic aspect identified in the teacher's thought. The activity analyzed is part of the questionnaire. Find below the wording of the question:

Please mention two criteria that a teacher must consider to develop argumentation in science class.

Fragment of the questionnaire developed for this research.

Text 1 (Initial): Children's intellectual development, ability to understand and analyze.

Text 2 (final): Text 2 (final): The gift of listening to all the answers so that you can go back and ask new questions so that students can explain their thinking, in order to develop their critical thinking.

The context that surrounds us, the age of students, providing the opportunity for children to express what they know through various activities.

Fragment of the questionnaire developed for this research.

In the first text, one may notice that the conceptual perspective of learning is far from the sociocultural proposals – which support the development of argumentation in the class, because, according to the teacher, learning depends on the development of the individual. In the second text, one identifies the elements that highlight the relation between teachers, students, knowledge and context. In this answer, we see that the teacher acknowledges her role as she states that she must listen to her students to rethink the questions or to, based on them, ask new questions that allow expressing and developing critical thinking, one of the central goals of science teaching, in which argumentation plays an important role. Students are recognized when they are accepted as individuals with knowledge and promoters of their own learning; knowledge is recognized when the teacher says *we must listen to their answers*, the analysis of the content of student participation to foster further discussions is implicitly valued, and so is that of the context, when she explains the importance of knowing her students, as an element or factor needed to give meaning to the discussion in communicative exchanges.

In class, the didactic aspect is analyzed in the questions the teacher poses to her students.

Table 3. Fragments of class in which the types of question used by the teacher in class are identified.

Fragment of class 1	Fragment of class 3
1:42 T: And what is the wood that comes from trees? 1:43 Ss: natural 1:44 T: what kingdom? 1:45 Sa(1): what kingdom? 1:46 So(x): plant kingdom 1:53 T: why ** no no no them them 1:54 Ss: because it comes from the leaves of trees and because it is from the plant kingdom… 1:62 T : Artificial 1:63 Sa(1): because it is already processed 1:64 T: it is already processed, good 1:65 Sa(1): here there was a pitcher with some water, right? So some considered it by the glass which is which is artificial and we considered it because of the water that was there. So we put art natural 1:66 T : What is water?	1:255 T: violin, then the question is, it was really nice of you Johnatan do you think the violin will sound the same underwater? now based on what we have said tell me why or why not, Emanuel sit down, do you think that the violin will sound the same underwater? 1:256 Ss: no::: 1:257 T: no::: my love, everyone will tell me why, but raise your hand and let's listen to who is going to speak, Emanuel ((he remains silent)) Carlos 1:258 So(1): * no, because under the water it sounds more slowly 1:259 So(2): sounds? 1:260 T: leave it to him, we are respecting, (calls a student) 1:261 Sa(3): * I think so. 1:262 T: why? 1:288 T: now let's, those raising hands, no, let's listen to Julian, do you think the violin will sound the same underwater? 1:289 So(10): No 1:328 T: but just now we were talking about where the sound moves better, whether through water or air or gases or solids, and is water solid? 1:329 Ss: * no::: 1:330 T: * what is water? 1:331 Ss: * liquid 1:332 Sa(18): it is a source of energy 1:333 T: what? 1:334 Ss: it is a source of energy 1:335 T: good what else? Speaking of states of matter, it is a liquid and what have we just said why is it best transmitted through solids?

Source: Authors' construction.

In the fragment of class one, we identify generalization questions (lines 1:44: *what kingdom?* and 1:66: *what is water?*). From them arises the relation of theoretical content with the situation studied. The other type of question identified in this episode is causal (línea 1:53), which invites students to explain the reason for an action or participation, mobilizing them to present evidence or justifications to support their statements. In the fragment of class three, we have identified other types of questions: predictive, causal or justification and generalization ones. Predictive questions invite the proposal of hypotheses and the questioning of possible behaviors of facts or phenomena (lines 1:255; 1:288); causal questions require presenting evidence to support statements (lines, 1:257; 1:262); generalization questions ask for the relation between the content of the participation and the concept analyzed (lines: 1:328; 1:330).

Characteristics of the model for teaching argumentation in science

A teaching model that promotes argumentation in science class has the following characteristics:

a) It considers that argumentation plays a fundamental role in science teaching. Indeed, in the teacher's thought, this was the obstacle identified in the first two stages of analysis (table 4). In them, the context of discovery is based on actions of observational and experimental order. In this way, they leave aside other elements which are part of this context such as cultural, social and political aspects, and which supported the questionings of the context of justification, used for many years to explain the relevance and consistency of scientific theories. Also, for the teacher, observation is the action that triggers the process of science construction: "to draw conclusions, it is first necessary to observe and experiment objectively and directly" (Fragment of the answer given by one of the teachers). This deeply ingrained epistemological position, which possibly affects teachers' performance and student learning processes, by giving vital importance to sensory actions at the expense of actions of cognitive-linguistic nature.

However, in Table 4 it can be noted that at the end of the process the teacher takes a more flexible approach to the conception of science and to how it is constructed. The teacher recognizes that communicative interaction between subjects leads to constructing, validating or expanding conclusions. This view is in line with the approaches that value communication processes and, in them, argumentation as a necessary action for the construction and progress of scientific theories (GIERE, 1999).

Indeed, this perspective facilitated the teacher's promotion of an appropriate environment in class to develop argumentative processes with explicit intentions. As discussed below, such environments allowed students to express their knowledge and contrast it. She also valued her students as protagonists within a dialogic process that intended to reach joint understandings of the phenomena studied.

b) It considers argumentation as a dialogic process in which it is essential to take into account the context of students. This is precisely what the teacher's thought achieved after her participation in the Spaces of Critical Reflection (see Table 5). She moved from a conceptual perspective of argumentation that values more the structure of arguments to a perspective that also recognizes context, attitude, decision-making and group work. In short, the teacher's thought is characterized by accepting that to argue is a dialogic process in which it matters:

• To value dialogic interaction between people and support discussions with evidence and statements.

• To require the creation of argumentative environments, a task for both teachers and students.

• To promote attitudes of respect and listening to the other in classroom.

The above aspects were fundamental for the teacher to succeed in bringing class content close to the students, content from everyday life that allowed free and spontaneous expression of knowledge and contents. In addition, she was able to support the discussion of the content with questions of causal and predictive nature. This helped students participate in discussions which went beyond the mere description of phenomena or facts and engage in discussions in which it was necessary to use and present evidence to support their participation.

c) To consider that promoting argumentative processes in science class requires accepting that to argue is a social dialogic process based on the development of group work. In such group work, in addition to involving students in discussions and criticism of their knowledge, an important place is given to dialogic inquiry. Such inquiry recognizes first the creation of argumentative environments that incorporate the context of students and, secondly, the problematization of knowledge.

In this sense, it can be seen in Table 6 that the teacher explicitly recognizes the teacher-student-knowledge-context relationship. Teachers' recognition occurs when they are required to have a favorable attitude towards listening to students. Listening is an essential principle if we want to reconsider the concerns of our students or ask new questions based on those concerns to encourage them to express and develop critical thinking, which is one of the central goals of science teaching, and is where argumentation has an important place. Students are recognized when they are accepted as individuals with knowledge and promoters of their own learning. Recognition of knowledge occurs when the teacher says that we must learn to listen and value the content of the participation of our students to foster new debates. Finally, recognition of the context occurs when the teacher explains the importance of knowing her students, their everyday life, to articulate themes to their environment and to give meaning to the discussions in communicative exchanges.

The achievements in the teacher's thought allowed her class performance to be characterized by the combination and application of questions of different nature and, with them, by the involvement of students in group actions mediated by debates and criticism of their participation. In this sense, we have identified questions of a different nature, as seen in the fragments of questions asked by one of the teachers in her classes:

• Descriptive: *what happens when you strike a bell?;*

• Generalization: *what is sound?, what do you do to make a particular instrument sound?;*

• Causal: *Why do we hear the sound of a train before it passes by our side?, why is the sound produced by the bell of a house heard in every room?;*

• Predicative: *do you think the violin will sound the same underwater?, now from what we have said tell me why or why not, Emanuel, sit down, you think the violin will sound the same underwater?*

Table 4. Characteristics of the epistemological aspect in the teacher

Analysis time	One	Two	Three	Four
Relation between argumentation and construction of science	…there should be experimentation, observation… and dialogue with other people	by living in a context students observe and experiment and therefore can already speak and narrate about that reality	... by asking questions ...by promoting the observation of substances and asking questions based on the observed…	… to draw conclusions, it is first necessary to observe and experiment objectively and directly… Then socialize with other scientists to discuss, validate the evidence obtained and with them expand, share, discuss these experiments and conclusions, and draw others.
	Traditional approach to constructing science		Flexible approach to constructing science	
	Absence of argumentation as an objective		Argumentation as an objective	
Goals of science teaching	To explain the concept of matter	To compare the different kinds of energy that we continually use at home	To orally expresses argued answers to questions.	

Source: Fragments of answers prepared by one of the teachers in reflection meetings. Authors' construction.

Table 5. Characteristics of the teacher's conceptual aspect

Analysis time	One	Two	Three	Four
Concept of argumentation in science	To argue in science supposes deducting, making clear… so that one reaches good communication	Arguing... considering the value of respect and listening, starting from everyday life.	Arguing ... when each student expresses what he or she considers... and presents evidence... to be able to make decisions (.) of group work	Arguing... is to express what they understand from their own everyday life, to refute concepts if necessary, to say the reason for things and explain creating an atmosphere of socialization...
	Emphasises the structure	In addition to the structural part, highlights the attitudes, values, context, and group work		
	Dogmatic content	Problem posing content		
Content type	Matter is: all we can see... everything that occupies a place in space.	We use solar energy to… it can be used to...	... So when we turn on the radio... therefore, we can hear the sound of a train before it passes by our side.	

Source: Fragments of answers given by one of the teachers in reflection meetings. Authors' construction.

Table 6. Characteristics of the teacher's didactic aspect

Analysis time	One	Two	Three	Four
Criteria for teaching argumentation	Children's intellectual development Experiments	...Teamwork in which they can participate and express their opinions and support or challenge… arguing the contents given...	...freedom... a question... group work based on a theme	The gift of listening to all the answers... ask new questions... The context... Group activities, in which they express their ideas and then share them with the rest of the group.
	Emphasises the structure Dogmatic content	Criteria: teacher, students, learning. Management: group activities Predictive and justification questions		Criteria: teacher, students, knowledge and context Management: group activities
Type of questions asked by the teacher	what kingdom?; ¿what is water?; and what material is iron?	... why do we say that at 10 a.m. it will get warmer? Jorge, what do you think? why? ... does it look like it's going to rain?...	…Why do we hear the sound of a train before? Well, he says it is because of the bell. What happens to the bell?	

Source: Fragments of answers given by one of the teachers in reflection meetings. Authors' construction.

Conclusion

The purpose of this research was to propose a model for teaching argumentation in science class that allows visualizing relationships between three basic components of the models: the epistemological, conceptual and didactic ones. For this, it is important first to state that teachers should deepen their knowledge of argumentation in class, i.e., of the epistemological, conceptual and didactic aspects, and, secondly, that this construction invites relating two dimensions: teacher thought and performance with regard to argumentative processes. Thought in terms of the process of argumentation itself and the relations between arguing and constructing knowledge. Performance in terms of the incorporation of argumentation in science teaching and learning.

In this regard, the work developed on the different findings identified in the teacher allows us to conclude the following on the three pillars on which the model is based:

a) With respect to the epistemological aspect, the model must first consider the role of argumentation not only in the construction and progress of scientific theories but also in science teaching and learning. Secondly, it must explicitly incorporate argumentation into the lesson plans as one of the competencies to be developed in science class, and also accept it from the conceptual aspect as an indispensable epistemic practice to the co-construction of school science.

b) As for the conceptual aspect, the model must highlight three fundamental aspects. First, accepting that argumentation is a social and dialogic process that implies recognition of the other as a possessor of knowledge; second, accepting the importance of intensive use of language in science class, and with it, of favoring debates and discussions on the concepts taught and, third, accepting that the contents to be taught and learned in class should recognize the context of students as an articulating axis of knowledge and the new meanings that one expects to co-construct in science class.

This requires that the various lesson plans propose activities in which a science close to the students materializes, a science that means something to their lives and that can be coconstructed from concrete dialogic interactions proposed in science class.

c) Regarding the didactic aspect, the model must recognize three relevant elements. First, the acceptance of classes from an argumentative perspective, regardless of theoretical frameworks. Second, the recognition of the question as a dynamic of an intensive communication model, in which teachers bring school science closer to their students and prioritize an interactive, dialogic model of debate and co-construction of meanings. Third, the valuation of students as knowing, social, and contextual subjects. Fourth, the recognition of the incorporation of both argumentative processes and products constructed by the subjects involved in the discussions into the argumentative process deployed in the classroom. Fifth, and last, the valuation, in the development the argumentative processes, of not only conceptual aspects but also contextual, social, political, cultural, aesthetic aspects, and many others.

In short, we believe that this proposal may help teachers to reflect on their thinking and performance regarding the use of argumentation in their science classes. Also, it may help them be aware of their personal position on the epistemological, conceptual and didactic dimensions as tools to perform much more meaningful argumentative practices in science classes.

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