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Analysis of the forms of argumentation of teachers in training in the context of a socio-scientific issue

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ABSTRACT

The aim of this study is to analyze the forms of argumentation regarding a socio-economic question related to the consumption of coffee by a group of 32 students with a Bachelor's Degree in Natural Science and Environmental Education. For this, a rubric was used to analyze three fundamental aspects: content, structure, and position or response in the face of the arguments. The results indicate that the students can produce arguments with content, but difficulties are observed in regard to their developing arguments with structure. Furthermore, the students tend to avoid debate situations, which does not allow for the improvement of their arguments. Despite that, the participants acknowledge the importance of including argumentation in their training, and they are aware of their difficulties. This indicates the need to promote a greater number of studies that would allow the importance of argumentation to be included in the educational processes.

Keywords: Argumentation in the sciences, forms of argumentation, teacher training.

INTRODUCTION

Since ancient times, when philosophers began looking for the reason for things, argumentation achieved a fundamental position in the construction of knowledge and of public debate. At the time, logic and rhetoric were the fields that showed an interest in argumentation (Bochenski, 1966; Aristóteles, 2000). Logic kept its central importance throughout the whole of the Middle Ages (Beuchot, 1987) and even up until the beginning of the modern age, when it was eventually relocated along with other elements that were condensed into what has since then been called method or methodology, that is to say, the rules of scientific work (Cristancho, 2013).

This also caused logic to establish new ways of working and researching beyond argumentation as such (Garrido, 1991; Russell, 2013; Wittgenstein, 2012). In any case, argumentation continues to be an important component in the construction of knowledge. It is introduced in all professional degrees, and it has special relevance in training for the natural and applied sciences, as well as for the social sciences and humanities; not only to improve

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research skills and establish the appropriate perception of these types of sciences, but to also give meaning to the academic development of the students (Mcneill, González, Katsh & Loper, 2017; Evagorou & Osborne, 2013; Gültepe & Kiliç, 2013). At the same time, it has been proven that there is a positive relation between the knowledge of content of the people who use arguments and the number of arguments they produce during a scientific argumentation (Hakyolu & Ogan-Bekiroglu, 2016; Aktamiş, Hiğde & Özden, 2016).

With regard to this, research such as that carried out by Jiménez-Aleixandre (2010), Osborne (2010); Berland, and Lee (2012), indicate that scientific argumentation is a dynamic social process, where ideas are tested, given that those involved work to improve their approaches and persuade other people's ideas, making use of new data, evidence, and proofs.

In their research, it is suggested that argumentation does not arise naturally in most people and depends upon environments and practices (Osborne, Erduran and Simon, 2004; Evagorou & Osborne, 2013; Mcneill, González, Katsh and Loper, 2017). With regard to this, much of the research on reasoning has focused on the available evidence; for example, studying how data is used in the argumentation process (Hogan & Maglienti, 2001; Kolstø, 2001; Sandoval & Millwood, 2007; Nielsen, 2012; Zeidler, Herman, Ruzek, Linder and Lin, 2013).

Studies undertaken by Asterhan and Schwarz (2007), Kuhn (2010), Berland and Lee (2012), show that favoring the argumentation process in the classroom contributes to the building of solid points of view. For instance, debating in class improves the structure of arguments, the understanding of content, and helps to improve the learning of that knowledge. For example, Duschl (2008), Jiménez Aleixandre and Erduran (2008); Berland and Lee (2012); Evagorou and Osborne (2013); Namdar and Shen (2016) point out the importance of including argumentation in the pedagogic processes, because it is an opportunity to have access to scientific knowledge and a way of understanding scientific practices.

Other works analyze how environments of debate in the classroom account for the type of discourse the students in a training program are taking on and how they use their knowledge of science and technology in regard to a socio-scientific issue (SSI, from now on). In fact, if argumentation is the exercise of constructing, proposing, and socializing points of view in favor of a thesis or theoretical position, discussion is the process that takes place when diverse arguments come into confrontation. This allows for them to be polished or improved, which is a central component of the training in the social sciences, as a way to help the students make the concepts and theories of a certain discipline their own, and it is also a way for them to get involved in the social construction of scientific knowledge (Erduran and Jiménez Aleixandre, 2008; Chi, 2009; Celik & Kilic, 2014; Namdar and Shen 2016).

The study of the form of arguments and of debating within teacher training environments assists the process of the construction of knowledge in scientific education that allows for future dialog and social processes in the classroom (Plantin and Muñoz 2011; Torres, 2016). It is not possible to expect argumentative processes in students if there are no teachers trained to foster and develop them.

By way of summary, the argumentation processes are used to indicate the mental negotiation processes that can be externalized for the students' debates that defend their ideas about the SSI. This helps decision making and the ability to search for information and act critically (Kolstø, 2001; Nielsen, 2012; Torres and Solbes, 2016; Azar, 2010)

In the framework of these discussions, and taking into consideration that more studies are necessary in order to analyze the perspectives of reasoning of the students in depth, such as finding out what type of information they use when faced with SSI, and what type of tests they use to base their decisions on, this article presents the results of a study that focused on identifying the forms of argumentation that take place in the discussions of small groups when approaching an SSI. It is related, in this case, with the consumption of coffee by bachelor's degree students of Natural Science and Environmental Education at a Colombian university.

As a point of reference, as well as the previously referenced precedents, works that had forms of argumentation as their object of study were taken into account to carry out this study. The majority of the research has been interested in the quality of the arguments, despite the fact that, as Dawson and Venville (2010) indicate, there is a lack of consensus as to the meaning of assessing the quality of argumentation in research with SSI.

Without a doubt, this is an element that makes it difficult to compare the results obtained in the different investigations. However, the bibliographic revision that was carried out in the development of this document allows us to consider some of the procedures that may help in making an analysis of the arguments in the development of a didactic sequence.

For example, Means and Voss (1996) highlighted that the strength of arguments can be associated with certain criteria, such as the acceptability of the reasons of the argument and its relevance, which is related to the reasons that support the conclusion or affirmation of the argument.

On the other hand, Sampson and Clark (2008) indicated some aspects that allow us to analyze the quality of the students' arguments:

> (1) the structure or complexity of the argument (i.e., the components of an argument), (2) the content of an argument (i.e., the accuracy or adequacy of the various components in the argument when evaluated from a scientific perspective), and (3) the nature of the justification (i.e., how ideas or claims are supported or validated within an argument). (p. 449).

Other authors who commented on the same topic are Zohar and Nemet (2002), who analyzed the implementation of a didactic unit to investigate how the use of the knowledge of content affects the construction of arguments and argumentative skills in secondary schools in Israel.

These researchers used different methods to evaluate the quality of the arguments. For example, to analyze written work, they used a rubric that states the following: a) one justification, two justifications; b) structure of the argument when there is no argument, a simple structure supported by a sole justification and two compound structures, the justification of which is supported by one reason that, at the same time, usually explains why the first justification should be accepted.

To analyze oral argumentation, they made a division of recordings of units of analysis that were classified into different categories: explicit conclusions, implicit conclusion, consensus, opposition, and counter opposition. In their conclusions, they affirmed that the instruction of the teacher improves the arguments given by the students in an SSI related to genetics (Zohar & Nemet, 2002).

Similar results were obtained by Venville and Dawson (2010), where they concluded that the group of students that received instructions about argumentation improved the quality of their arguments. These authors indicate that it is important to consider the information and the guarantees as a whole. At the same time, they proposed a scheme that permits us to analyze the complexity and quality of the arguments that range from level 1 to level 4, as follows:

Level 1 refers to assertions or conclusions that do not present a justification; Level 2, arguments that represent assertions or conclusions based on information or guarantees; Level 3, arguments that present assertions based on information and guarantees. They also present the use of guarantees or qualifications. Level 4 refers to arguments that present affirmations or conclusions based on information and guarantees with the use of supporting qualifications.

At the same time, for Penha (2012), the quality of an argument must be based on two foundations: the quality of the arguments used in different ideas or propositions and the quality of the way by which they are opposed. This same author indicates that the quality of the arguments must be related to aspects like the quality of the structure and the quality of the content.

In fact, for Penha (2012), the quality of the structure is associated with the level of complexity of the argument. This could be related to the number of elements of the argument, particularly information, justifications, and counterarguments, whereas the quality of the content of the argument is related to the acceptability and the relevance of the argument.

Even when previous studies do not allow us to infer what is required for the acceptability of the given reasons; it is assumed that they are necessary to support the affirmation of the argument, which may give rise to coherent or incoherent conclusions. In this article, it is considered that the acceptability of the reasons is one of the most important elements in the quality of the arguments. For this reason, if a proportion of the argument uses unacceptable reasons, the conclusions will have no foundations.

Apart from the formal logic aspects, there is another aspect of the quality of the arguments that is linked to the coherence of the structure of its components. The authors mentioned allow us to find some of the main elements, such as conclusions supported by data and justifications that show the relation between data and conclusion.

Therefore, to evaluate the quality of the arguments in the students' forms of argumentation in this study, the following aspects mentioned by Sampson and Clark, (2008); Venville and Dawson, (2010); and Berland and Lee, (2012) were taken into consideration. They imply quality of the argument (content and structure) and quality of opposition among the arguments. The former examines the complexity of the argument based on its acceptability, coherence and adequacy (content of the argument), and the use of information, premises or guarantees (quality of the structure of the argument). The latter refers to the manner of opposing argument-counterargument, refutations. (See *Infra*, Methodological aspects, Table 3).

This study proposes to analyze the forms of argumentation by examining the content and the structure of the arguments, as well as the process of refining, the construction of which is implied in the discussions. Thus, this study was performed considering that the pedagogic practices that include debate and discussion allow students to think and reflect upon aspects, such as the perception of a learned science and the applications of scientific concepts, as well as the link between science and social, ethical, political, and environmental aspects. It is also an opportunity for teachers to generate attitudes and behaviors of participation.

In this sense, the study responds to the following questions: *What are the conceptions of argumentation among a group of student teachers of a Bachelor in Natural Science and Environmental Education degree? What are the kinds of argumentation of a group of student teachers of a Bachelor in Natural Science and Environmental Education degree?*

METHODOLOGICAL ASPECTS

Research method

The research presented in this article was carried out through a diagnosis, followed by an intervention and a reflection (Martínez, 2010; Evagorou and Osborne, 2013). Its objective was to identify the forms of argumentation used by a group of students of a natural science teacher-training program when approaching a SSI related to coffee consumption, from a laboratory practice experience and the development of a number of activities. It is qualitative research with a case study approach (Yin, 2003). The data obtained were based on written answers of the students to the outlines of the activities and the transcription of lessons recorded in audio.

Sample/study group

The research was carried out in a public Colombian university located in the Department of Boyacá, in the Andean region of Colombia. Thirty-eight (38) students who were sitting for the subject *Experimental Workshop on Natural Science* participated. The students were in the eighth semester of the Bachelor's Degree in Natural Science and Environmental Education during the first semester of 2015. The ages of the participants ranged from 20 to 26 years of age, with 15 males and 23 females.

The development of the didactic sequence took place in workgroups. In this way, 12 groups of 3 to 4 students each were formed, according to the students' interests. For writing this article, the names of the students will remain anonymous. They were given fictitious names starting by the letter of the workgroup they belonged to when they performed the activities. So, for example, all the names of the members of Group A start with the letter A.

The students that took part in the study have already completed 80% of the disciplinary and pedagogic contents of the Bachelor's Degree in Natural Science and Environmental Education program. For this reason, it is presupposed, that they have a good conceptualization of the scientific concepts and possess the necessary requirements to apply what they have learned in the classroom to different everyday situations. So, what is being evaluated is: what the students are capable of doing as regards scientific argumentation processes, how they do it, and what obstacles they find.

Phases of the study

This study was based on the teaching of the SSIs approach which, due to their controversial nature, and for being scientific issues with social implications, they are conducive to debate and promote argumentation (Dawson and Venville 2010; Evagorou and Osborne 2013; Torres and Solbes, 2016). Colombia stands out due to its production and consumption of coffee. For that reason, the topic of the SSI chosen was coffee consumption. This is a controversial topic due to the harmful or beneficial effects of coffee.

On the one hand, coffee is a beverage that is widely consumed worldwide and its popularity is still growing. However, the caffeine present in coffee may cause the stimulation of the central nervous system and an addiction to that substance. Ingesting coffee has also been related to illnesses, such as cancer and arteriosclerosis, despite the phenolic antioxidant components that are supposed to have a protective effect. As there are controversial aspects with regard to health, these elements make the consumption of coffee an SSI of interest to the students.

For the development of this study, various types of activities were developed that involved actions to carry out an initial evaluation, the work sections, and the reflection about the work done. In each of the activities, the answers to the questions formulated in questionnaires were analyzed. The audio recordings produced by the participants were also analyzed. For this, four group activities were programmed, as shown in Table 1:

Table 1. Activities that are part of the research in order to identify the contributions of socio-scientific issues to the development of argumentation. Source: The authors.

N.	ACTIVITIES	AIMS	DURATION

1.	Introductory guide to scientific argumentation and its importance in the training of science teachers.	To present and discuss different theoretical perspectives with regard to the conceptualization of the argumentation and the SSI.	2 sessions of 120 minutes each.
2.	Development of an experimental guide concerning the extraction of caffeine.	To analyze aspects of the experimental practices and their relation to dialogical processes.	2 sessions of 120 minutes each.
3.	Development of a didactic sequence about the consumption of coffee.	To analyze the types of arguments that the students use to approach an SSI referring to the consumption of coffee.	3 sessions of 120 minutes each.
4.	Reflections about the implementation of the didactic sequence and the argumentation processes in teacher training programs.	To analyze dialogic situations in each one of the groups.	1 session of 90 minutes.

The first one was related to an introduction to scientific argumentation and the SSI. Its objective was that the students discussed different theoretical perspectives and reflected upon the incidence of argumentation in the teaching of the sciences. Some of the questions asked in this session were:

1. What do you understand by argumentation in sciences? What does it include?
2. Do you agree with the ideas expressed in the text? Justify your answer.
3. What conditions are necessary to carry out argumentative processes in the science class?
4. Mention examples of fields of study in which scientific argumentation studies can be carried out. How can this be done? (If it applies, choose a class and base your answer on it).

The second group activity was an experimental practice related to the extraction of caffeine that would allow a discussion about the use of chemical reagents. Given the extension of the guide, some of the questions, some of the questions made to the students in said experimental practice are shown below:

1. What is the role of sodium bicarbonate in the experience?
2. Why is trichloromethane used in the practice?
3. What is the role of anhydrous magnesium sulfate in the experience?
4. Describe the distillation process. The data of boiling temperature coincide with those reported in the literature. Justify your answer. Which is the most volatile component? Which component is collected in the test tube? Which component remains in the distillation flask?

The third group activity was related to the development of a didactic sequence about the consumption of coffee. The description of the activities and the questions posed appear in Table 2 and a fragment of the guide of the didactic sequence appears in Figure 1:

Table 2. Description of the didactic sequence used. Source: the authors.

Aspects of the sequence	Description and intention	Questions of the didactic sequence
HISTORY OF THE DISCOVERY OF COFFEE	In this section, the students are presented with a legend that explains the discovery of coffee and the origin of its use. The students are encouraged to refute or justify the story in the sense that they favor discussion situations. Space is allowed for hypothetical connections with more concrete arguments.	1. Explain how Kaldi's argument could be justified or refuted.
THE CHEMISTRY OF COFFEE	Students are presented with the components of two very common types of coffee here in Colombia (Arabica and Robusta). The students are requested to study the information given and make a decision as regards the type of coffee they should consume arguing why one is better than the other.	2. Based on the data presented, which coffee would you prefer to consume and why?
THE AROMA OF COFFEE	Science is reflected in everyday activities. Information with respect to the characteristic aroma of coffee is presented and the student is asked about different types of coffee. The objective is that the student questions the significance of the different types	3. Why does coffee have that particular aroma? Are instant coffee and whole-bean coffee the same? How are they different?

	of aromas in commercial coffee.	
THE ACIDITY IN THE COFFEE	The acidity perceived in the coffee infusion has always been recognized as an important attribute of the quality of the coffee. However, in many cases, its importance is ignored in the biological processes. It can also be a tool to articulate concepts of biology and chemistry.	4. Is the acidity in the coffee important? What does it refer to?
COFFEE INDUSTRIALIZATION	The aim of this section is that students question the information that appears on the labels of foodstuffs and electronic devices. They can also analyze its veracity.	The following situation is presented in this section: 5. Mario Pérez wishes to implement thermal treatments in his coffee industry. However, considering the number of technological artifacts that are offered nowadays, he requires the guidance of a professional in science in order to make the best choice. What recommendations would you give Mario?
COFFEE AND HEALTH	In this segment, the students are presented with aspects related to the use of solvents in the industrialization of coffee. Thus, the students can investigate the uses and effects of some products. The students are also given the chance to come to a decision as regards what food industries and the general public should do.	6. Look up information about CH_2Cl_2, chloroform, and benzene. Explain the effects of the substances mentioned above on human health and the environment. 7 What other substances of domestic use contain methyl chloride?

THE CHEMISTRY OF COFFEE

Coffee contains a number of biochemically active substances; one of the most important and well-known is caffeine, which is a xanthine derivative. In addition, it is a considerable source of polyphenols and phenolic compounds, which may contribute in quantity and variety to the entry of antioxidants. Many chemical compounds have been identified in coffee beans and said compounds react and interact in all the phases of coffee processing in order to produce a final product with great diversity and complexity of structures.[1] In Colombia, there are different varieties of coffee. For example, the Arabic and the Robusta, which are qualitative and quantitatively different in their chemical composition, as shown in the following table:

Componente químico	Arábica %	Robusta %
Polisacáridos	50,8	56,40
Sacarosa	8,00	4,00
Azúcares reductores	0,10	0,40
Proteínas	9,80	9,50
Aminoácidos	0,50	0,80
Cafeína	1,20	2,20
Trigonelina	1,00	0,70
Lípidos	16,20	10,00
Ácidos alifáticos	1,10	1,20
Ácidos clorogénicos	6,90	10,40
Minerales	4,20	4,40
Compuestos aromáticos	trazas	trazas

Source: Quintero (n.d)[1]

The antioxidant property of coffee has been proven, which is quite homogenous and potent. The research carried out on these two types of coffee proved that the Robusta type doubles the antioxidant capacity of the Arabica, due to its higher content of chlorogenic acid. Although both are usually mixed to produce coffee with different flavors, the antioxidant capacity of these combinations slightly varies.

2.a. Using the data presented above, which coffee would you prefer to consume and why?

Figure 1: Sub-section of the sequence, which corresponds to the section Coffee and Health

Finally, in the fourth session, a guide that allowed for the analyzing of the dialogic processes of the sequence was developed.

Data Sources and Analysis

For the evaluation of the answers to the questions presented to the students, a qualitative analysis was carried out. From this point of view, with the development of the proposed SSI, the social interactions among the students were taken into consideration. The transcription of the information was carried out from units of analysis from the documents written by the participants and the recordings made around the discussions in the work groups. Each one of the units was analyzed according to its structure and the quality of the argument, in order to make comparisons, to analyze the performance and the participation of the students in each SSI question used, considering the fragments of the chapters of interest.

With regard to this, a content analysis was carried out, taking into consideration the rubric in Table 3. The review of each one of the written answers was corroborated: first, individually by each author, through a guide of answers created by the first author and revised by a professor who specializes in Biochemistry and another one who teaches Didactics of the sciences, with 5 and 8 years of experience, respectively. Afterwards, the answers were jointly corroborated by the authors.

The answers were classified by associations to general concepts that include a broad category that holds some kind of relationship between them. The systematization of the answers to each of the questions was done on the basis of the analysis of the answers given in the questionnaire by students. Afterwards, an interpretation was made of the most common ideas. Also, an effort was made to understand the approach taken by the students toward argumentation in the sciences.

A classification of the answers to determine the kinds of argumentation was carried out according to the rubric shown below, where the following levels, three (3) being the highest and one (1) the lowest, are proposed. The aspects considered in the analysis of the arguments produced by the students (Table 3) are presented in the first column. This rubric was done according to methodologies used by Sampson and Clark (2008); Zohar and Nemet (2002), Venville and Dawson (2010); Penha (2012), and it was previously described in the introduction.

Table 3. Criteria used to analyze the ways of argumentation of the students of the Bachelor's Degree in Natural Science and Environmental Education. Source: The authors.

Aspects of analysis	Description	Level	Description of points
CONTENT OF THE ARGUMENT	The use of data, concepts, affirmations, or guarantees in the arguments. Evaluation of the accuracy of the conceptual references.	3	- Affirmations supported by data and explanatory scientific concepts backed up by sources of information.
		2	- Arguments that contain data and concepts, but some of which are used incorrectly, inaccurately, or incompletely.
		1	- Arguments that present neither information nor explanatory scientific concepts.
STRUCTURE OF THE ARGUMENT	The complexity of the argumentation verifiable by the acceptability, coherence, and competence of the argument.	3	- Arguments that maintain coherence between the information, the justifications, and the conclusions; that is, that the justification is sufficient to validate what wants to be defended.
		2	- Arguments that are coherent but require greater complexity and relevance.
		1	- Arguments that are neither coherent nor sufficient to reach conclusions.
FORMS OF DISCUSSION	Counterarguments, refutations, reaffirmations, or acceptance in response to the arguments of other classmates.	3	- In response to arguments which lack content or are incoherent, proposes opposing ideas and supports them with concepts, data and sources of information. - In response to coherent, but incomplete arguments, proposes concepts, data, and sources of information that go deeper and improve the argumentation.
		2	- In response to diverse arguments proposes opposing or complementary ideas, but without supporting them with sources of information or using concepts inaccurately.
		1	- Accepts ideas without questioning them in any way, complementing them, or explaining the argumentation.

ANALYSIS AND RESULTS

According to the four stages presented in the methodological phases, the results are described below.

Results of the application of the introductory guide to scientific argumentation

The guide allowed the evaluation of diverse aspects, such as the conceptualization of the argumentation of the students and their pedagogic and didactic implications in the classroom. The aim of the guide was to show the students different theoretical perspectives regarding the conceptualization of scientific argumentation and its implications for the teaching of scientific concepts, as well as its precedents, and the differences between argument and argumentation.

Conceptualization of scientific argumentation

Once the reading of the introductory guide to scientific argumentation was finished, some general questions were brought up. They allowed a description of the concept of argumentation given by the students: its implications in the classroom and its effect on the teaching of the sciences. In the following table, the main categories found in the conceptualization of the argumentation are presented. The frequency is expressed by indicating the number of groups that made affirmations in relation to each category.

Table 4. Categories of the conceptualization of the argumentation in the participating groups from their written reports. Source: The authors

Aspects	Categories	Examples	Frequency
Pedagogic and didactic processes	Argumentation and context	The disciplinary, experiential, and didactic components are necessary to argue.	2
	Validation of ideas	It is a thoughtful process that allows for the contrasting of theory with what we think.	5
Epistemological	Relation between argumentation and science	Capacity to explain and support ideas with science.	6
		Science is an argumentative process that is useful to formulate theories.	1

As shown on the Table, the main aspects identified are: a) pedagogic and didactic implications required for the argumentation; b) the relation between science and argumentation, where students point out elements of the epistemology.

It is observed that six groups associate argumentation with the capacity to explain and support ideas, making emphasis on the need to know how a scientific concept arises and develops, and the relation that is established between argumentation and science. This aspect highlights the need to create critical spaces that permit students to justify why they think that way and not in another. An example of this is the intervention of Group E (GE).

> GE. “The argumentation is an important aspect of the sciences given that one should have information to theoretically support and prove the arguments. It is mainly based on having knowledge of a topic and being able to explain it. This allows for one’s own points of views being taken into consideration and for other people`s ideas being respected.”

Five groups highlighted that argumentation is a thoughtful process that allows one to contrast ideas and review one`s own ideas on theoretical grounds. They emphasized that argumentation requires interpretation, comprehension, and analysis. For example, groups G and I indicated the need to learn to identify relevant arguments on which to base solid points of view.

In general, the affirmations of the students give relevance to the use of information as a necessary condition for the advancement of scientific knowledge and the validation of the arguments expounded; reaffirming what was said by Sarda and Sanmartín (2000). It is observed that the groups made emphasis on the need to have references to be able to make argumentative processes. This allows for light to be shed on the difference between opinion and argumentation. There were also shown to be categories that value argumentation beyond merely the informative aspect.

The participants indicated that argumentation is a necessary process in the validation of ideas and they acknowledge how argumentation has allowed for the advancement of scientific knowledge and for making reflections in order to contrast one's own opinions with the theoretical fundaments. Similar aspects were raised by Dimopoulos and Koulaidis (2003), Oliveras, Marquez and Sanmarti (2013), who stated that argumentation permits scientific and general literacy by linking social aspects to the study of scientific concepts.

On the conditions that promote argumentation in the classroom

The students were directly asked about the conditions that are required to promote the argumentation processes in the classroom. They highlighted aspects like sharing points of view, forming well founded opinions and collective comprehension, doing activities that allow their participation. They pointed out that this is a key element in the development of the learning processes.

Table 5. Analysis of the students' answers about the conditions required to promote argumentation in the classroom. Source: The authors.

Dimensions	**Category**	**Examples**	**Frequency group**
Methodological aspects of the classes	Participation in the classroom from:	Group activities	2
		Use of contextual situations	4
		Lab experiences	4
		Teacher's methodology	3
	Previous knowledge	Getting Informed and questioning the topic	5
Emotional aspects	Disposition	Motivation of the students and of the teacher	4

The previous table summarizes various conditions that are necessary to promote the argumentation processes. For example, the situations of participation in the classroom are highlighted: the development of group activities and the use of contextual situations. The participants also mention several aspects such as the teachers' and students' disposition. More frequently, the participants indicate the need to know more about the topic, as, according to them, this aspect helps them to be able to question the information and improve the quality of the argumentative processes. They also acknowledge that in order to offer quality arguments, previous knowledge of the topic is required.

It can also be observed how students refer to the didactic knowledge of the content. On the one hand, there is the disciplinary knowledge, given that the participants mention the information that appears in the books which is to be questioned, and on the other hand, the process that requires its teaching in the classroom where subjective aspects of the students and alternative conceptions are implicit. The importance of class participation is highlighted, so as to share points of view, which is an important aspect of argumentation. This coincides with what was said by Sampson and Clark (2008), who pointed out that argumentation implies the disposition to participate and the dialog to support or refute an explanation. It also coincides with what was indicated by Nussbaum (2011) that participation is built by means of a stimulation process that favors a profound comprehension of knowledge.

Below, some examples of the oral discourse are presented. The objective is to visualize the dialogical processes developed in the groups about argumentation in science. Neither the answers nor the expressions or the spelling mistakes are corrected. The clarifications appear in square brackets and in italics [*clarification*]. Some shifts or repetitions that are omitted are represented by parentheses.

By way of example, the comment made by Group B, responding to the question: "What is to argue in science?" is presented.

Chapter 1 – Group B

> Betty: "Argumentation is different from opinion because an opinion is a point of view that you give, but it is very subjective. It is not centered on anything much consolidated, theoretically speaking. In contrast, with an argument you can take a stance with certain parameters to guide you and give a good presentation on the topic. It could be by criticizing, looking at the impact, relating with topics for a formal development, to build the concept that you want to deal with."
>
> Beatriz: "Argumentation has a theoretical basis and has, like, an approval whereas an opinion is a divulgation to get to build the argument."

In this fragment, even when Betty makes emphasis on the need to get informed in order to offer a good presentation of the topic, she acknowledges the need to have an opinion as a mediating element of the argumentation, consolidated and based on a theoretical framework. Also, the participants highlight the need to have theoretical grounding and data to be able to argue and support ideas. In the previous fragment, for the students, it is possible to see that an opinion is intuitive whereas argumentation is a rational process that requires associations between concepts. They also mention an implicit element in the argumentation, which is, considering various different aspects or, as Betty puts it, evaluating the impact.

Analysis of the forms of argumentation from practical experiences in the laboratory

As a second aspect of interest in the study, an analysis of the quality of the arguments in laboratory practices was carried out. That implied the use of learned knowledge of natural science in order to explain the effects in the reactions observed in experimental practices.

The analysis of two of the questions proposed in the experience is shown below:

a) What is the action of sodium bicarbonate?
b) Why is trichloromethane used in the practice?

The answers to these questions are analyzed taking into account the three aspects of the forms of argumentation that were explained earlier in Table 3: content, structure, and forms of discussion. In order to analyze each one of the answers given to the two questions mentioned, the concepts and content elements that were evaluated in each one are presented:

Table 6. Criteria to evaluate the answers to questions from the experimental practice. Source: The authors.

Question	Minimum criteria for the analysis
What is the action of sodium bicarbonate?	CONTENT OF THE ARGUMENT: Point out the type of coloration and the change in pH that occurs in the analyzed coffee. Evaluate if the students use concepts and data accurately in the experience, such as pH value, and if they are capable of relating them; for example, explain why sodium bicarbonate is an alkaline agent and its significance, sodium bicarbonate as electron donor. The use of NaHCO3 allows for the extraction of organic acids, in this case, acids contained in the coffee, such as caffeic acid.
Why is trichloromethane used in this practice?	CONTENT OF THE ARGUMENT: Relate concepts, such as the density in the formation of two layers, considering the chemical composition of caffeine and chloromethane. Use the concepts of polar and non-polar compounds. Consider the structure of caffeine, given that in carbon chains of more than four carbons can easily be separated with organic solvents from the aqueous solutions. Use the concept of ionics, for example point out that ionic compounds are dissolved in polar solvents and the non-ionic compounds are dissolved in non-polar solvents.

The analysis of the answers given by the students is done using this rubric. In the case of the first question, the following was found:

Table 7. Synthesis of the forms of argumentation in response to the question: What is the action of sodium bicarbonate? Source: The authors.

ASPECTS OF THE ARGUMENT	VALUE ASSIGNED	EXAMPLES	Frequency
CONTENT	3	"Sodium bicarbonate is an alkaline agent."	3
		"Sodium bicarbonate is a basic compound."	4
	2	"Sodium bicarbonate reduces the solubility of caffeine in coffee."	5
		"Sodium bicarbonate contains carbon and oxygen."	3
	1	"Sodium bicarbonate eliminates part of the aroma."	1
		"Sodium bicarbonate eliminates liquid substances."	1
STRUCTURE	3	"Sodium bicarbonate is an alkaline agent and, for that reason, neutralizes the acidity of the coffee and generates CO_2."	3
	2	"Sodium bicarbonate is a basic compound, for this reason, it augments the pH of the coffee."	4
	1	"Sodium bicarbonate produces CO_2 because it contains carbon and oxygen."	3
		"Coffee has a dark color because sodium bicarbonate neutralizes it."	2
FORMS OF DISCUSSION	3	- Proposes opposing ideas and supports them with concepts, data, and sources of information that go into detail and improve the argumentation in response to arguments that lack content or are incoherent. - Proposes concepts, data, and sources of information that go into detail and improve the argumentation in response to arguments that are coherent but incomplete.	0
	2	In response to diverse arguments, proposes complementary ideas, but without supporting them with sources of information or using inaccurate concepts.	3
	1	The answer given by one of the members of the group is accepted, without going into detail.	9

The previous Table allows us to evaluate how the interventions of the students can demonstrate diverse concepts, but in a vague way. On a structural level, the concepts are not always used to respond to the question argumentatively. As a matter of fact, in the structure of the argument, we can see that to explain the effect of sodium bicarbonate in the experience, only 3 out of 12 students used the correct concepts such as alkaline, neutralization, and acidity. At the same time, only 4 groups out of 12 used concepts like basicity and pH properly.

We put "Sodium bicarbonate produces CO_2 because it contains carbon and oxygen" in the first level of the structure of the argumentation given that, even though this is true, this is not inferred from the practice where the extraction of caffeine is made. In fact, this argumentation is elaborated by the students by being inferred from other experiments (for example, the mix of acetic acid with sodium bicarbonate).

It is also concluded that there are no arguments that mention sodium bicarbonate ($NaHCO_3$) as an electron donor, nor arguments that mention its use for the extraction of organic acids. In general, it is observed that when it comes to a discussion, most of the groups tend to accept what is proposed within the group, with little supplementation, and no rejection.

In relation to the second question, “Why is trichloromethane used in this practice?” the content of the argument analyzes if the students explain why the use of chloroform permits the formation of two layers and why it facilitates liquid-liquid extraction. In the structure of the argument, it is expected of the students to relate concepts, such as the density in the formation of those two layers, and to use concepts like polar and non-polar compounds. They are also expected to explain that the structure of caffeine in carbon chains of more than four carbons can be easily separated with organic solvents from aqueous solutions, and that ionic compounds are dissolved in polar solvents whereas non-ionic compounds are dissolved in non-polar solvents.

Caffeine is quite a lot more soluble in an organic solvent that it is in water. So, by shaking the filter in contact with a certain volume of solvent in the decanting funnel, caffeine mostly passes to the organic phase. This is because the organic solvent is denser than water, which will form the lower layer, and it can be collected by simply opening the tap of the funnel. The glucose separates from the caffeine which is extracted in the organic solvent, in which glucose is not soluble. We make a synthesis in Table 8.

Table 8. Synthesis of the quality of the argument in response to the question about trichloromethane. Source: The authors.

ASPECTS OF THE ARGUMENT	VALUE ASSIGNED	EXAMPLES	Frequency
CONTENT	3		0
	2	“Trichloromethane is a solvent and allows for the formation of two layers.”	4
		“Trichloromethane forms two layers, like water and oil.”	4
		“Trichloromethane does not mix with water.”	1
		“Trichloromethane forms an organic and an inorganic phase.”	3
	1	“Caffeine is more soluble.”	2
ESTRUCTURE	3		0
	2	“Trichloromethane and caffeine are separated due to the polarity that allows for the formation of two layers.”	2
		“Trichloromethane decaffeinates coffee because it is a solvent and allows for the formation of two layers.”	4
		“Immiscible mixtures are found”	1
		“Increases the solubility of caffeine.”	2
	1		0
FORMS OF DISCUSSION	3		0
	2		0
	1	The answer given by one of the members of the group is accepted.	12

The use of trichloromethane in the laboratory practice is very illustrative, as it permits the formation of two layers. As regards this, the students mention that the function of this compound is to dissolve the caffeine. This allows them to identify that there is no difficulty in establishing arguments with content in Levels 1 and 2, which shows that the students pay attention to the physical properties and the macroscopic level of the practice, but that they do not go into detail when it comes to the chemical analysis of the practice, nor the background concepts that this implies (density, polarity, etc.)

This has effects in the structure of the arguments because none of the groups reach a level 3 when establishing coherent relationships between the concepts. In effect, they use concepts like "organic and inorganic phase" without establishing relationships between them. Moreover, when what happened is explained using the concept of polarity, the students take it for granted and do not go into detail as regards its explanation.

With respect to this, they could direct the argument by pointing out that although caffeine is soluble in water, it is even more soluble in trichloromethane, and for this reason, it is extracted using this organic solvent. Thus, the extraction using this compound separates almost pure caffeine from the basic solution.

Below you will find an example of the conversation of Group K. It is noticeable that they included some concepts like polarity of the substances and interpretation of the boiling temperatures. This greatly supports the argument with structure.

44.Kilian: Second question: Why is trichloromethane used in this practice?
45.Kevin: Trichloromethane or chloroform is used in this practice because it separates the organic and
46.inorganic phases, it is a useful reactive given the polarization that is present in its links. This
47. helps a lot with the organic tuning of the compounds.
48.Kevin: Does it describe what happens in the distillation? Does the data concerning the boiling temperature coincide with
49. the one reported in the literature? Justify your answer.

The previous fragment allows us to appreciate that the students have a good command of some concepts (polarity, trichloromethane, organic and inorganic phase, and reactivity). These concepts are used as premises until line 47, but in line 48 the students move on to another question straight away. That shows a failure to establish relations between the concepts and the actual practice carried out on the coffee. Neither is there an interruption, refutation, or complement to what was said by Kevin.

Development of the didactic sequence based on an SSI related to the consumption of coffee

In order to analyze the answers given by the different groups, below you will find the criteria that will allow the classification of the students' answers in the different levels, in each of the sections in the didactic sequence (cf. *supra*, *Table 2.)*

Some of the previous sections were chosen for the analysis that is presented in this article, as shown in Table 9:

Table 9. Criteria for the analysis of the content of the arguments in the didactic sequence of the activities that are the object of this article. Source: The authors.

SECTION OF THE DIDACTIC SEQUENCE	ASPECTS	DESCRICPTION If the students:
THE CHEMISTRY OF COFFEE	CONTENT	Use data about the composition of each type of coffee (for example, phenols, proteins, aliphatic acids, and antioxidants) and their functions in the body.
UHT PLANTS	CONTENT	Take into consideration the concepts such as direct or indirect heating, energy efficiency, heat exchange surface, organoleptic properties of coffee, and sterilization of coffee.

Next, the results of some of the items that form the sequence are presented.

The chemistry of coffee

In this section, the students were presented with a table that contains information about the two types of coffee most consumed in Colombia: Arabica and Robusta. This allows them to investigate the advantages of each one, look up the function of the antioxidants in the body, the effect of free radicals, and the importance of chlorogenic acid ($C_{16}H_{18}O_9$). The main question that was made was what type of coffee they would prefer to consume, and why.

Below, a synthesis of the types of arguments found is presented.

Table 10. Synthesis of the forms of argumentation in discussions about the components of two types of coffee. Source: The authors.

ASPECTS OF THE ARGUMENT	VALUE ASSIGNED	EXAMPLES	Frequency
CONTENT	3	Robusta coffee contains antioxidants, chlorogenic acids, and therapeutic properties that reduce the levels of glucose and insulin.	4
	2	Arabica coffee contains less sugar.	1
		Robusta coffee contains more caffeine and less sugar tan Arabica coffee.	3
	1	Arabica contains less antioxidants.	1
		Both types of coffee have good and bad attributes.	3
STRUCTURE	2	"We prefer Robusta coffee because it contains antioxidants, chlorogenic acids, and therapeutic properties that reduce the levels of glucose and insulin."	4
		"We prefer Robusta coffee due to its higher content of antioxidants that reduce free radicals."	4
		"We prefer Robusta coffee because of the carbon chains and the presence of chemical bonds."	1
	1	"We prefer Arabica coffee because it contains less sugar."	1
		"We prefer Arabica coffee because it contains more caffeine and less sugar."	2
		We prefer Arabica coffee because it contains less antioxidants.	1
	0	"Arabica is preferable because it doesn`t contain as many antioxidants, because consuming so many antioxidants is bad for your health."	1
FORMS OF DISCUSSION	3	- Proposes opposing ideas and supports them with concepts, data, and sources of knowledge that go into detail and improve the argumentation in response to arguments that lack content or are incoherent.	1
	2	- Proposes concepts, data, and sources of information that go into detail and improve the argumentation. In response to diverse arguments, proposes complementary ideas, but without supporting them in sources of knowledge	1

	or using inaccurate concepts.	
1	The answer given by one of the members of the group is accepted, without going into detail.	10

This aspect permits the evaluation of how a number of groups like C, H, I, and K, choose the type of coffee because of its antioxidant content. In the same way, other work groups choose the type of coffee because of its sugar or caffeine content. These approaches are valid because the students indicate that antioxidants inhibit the action of free radicals, helping to avoid cancer. The association and the effect that some components have in the body is analyzed; for example, explaining how antioxidants reduce the free radical content. The commentary of Group I is presented as an example.

> GI. "We choose Robusta coffee because it has more antioxidants and chlorogenic acids, and they possess therapeutic properties that reduce the levels of glucose and insulin. The amount of caffeine, in this case, is not important because what matters is the quantity of antioxidants and the benefits for the body. The handling at the moment of roasting the coffee is important, given that many properties can be lost. It can also be altered by external factors in the preservation and storage of the coffee."

In the previous commentary, the association of diverse compounds is observed. They point out, for example, the effect of chlorogenic acid on the reduction of glucose. They complement their comment with aspects that must be considered, as regards the quality of coffee, related to its handling and storage.

In groups like J, it is shown that they are not clear on the concepts in the second sequence. For example, the group indicates that it is necessary to choose the type of coffee that has a lesser quantity of antioxidants. They justify this by saying that an excess of anything can cause damage, and they end the discussion making a choice simply based on the flavor.

55. José: In my opinion, I would choose Arabica that has less antioxidants.
56. Janeth: Why?
57. José: because, anyway, I consider that consuming so many antioxidants can also
58. be bad for your body, we already consume some foods that contain those
59. antioxidants. If you drink Robusta, I analyze in my head that it is the strongest and
60. Arabica, that is even stronger, well, it has at least twice the process, so I would prefer
61. Arabica.
62. Janeth: Well, no, I would make my choice because of the flavor, actually. Let`s say,
63.you see the Table and the data, but I would be led more by the flavor, I would not know. Well, for me, that
64.would be valid, which of the two has a better flavor.

Thinking the argumentation processes from the use of technological mechanisms

In argumentation processes it is vital that the students reach conclusions that allow them to make decisions that have bases and promote actions for the improvement of the quality of life. It is also intended that they are capable of transforming their reality, resolving different situations on a personal, family, and work level. For this, the students were presented with a situation in order to consult the characteristics of each technological mechanism. The situation that was presented is the following:

> Mario wishes to implement thermic treatments in his coffee industry. Considering the number of technological mechanisms that are offered in the industry, he requires the guidance of a professional in the natural sciences field to make a better decision. What recommendations would you give Mario?

In this way, they could suggest Mario, the character in the situation, which best type of *Ultra High Temperature* (UHT) plant is based on their training as future graduates in natural sciences.

Considering the answers written by the groups, the classification is presented according to the choices of the participants.

Table 11. Synthesis of the forms of argumentation in discussions about the choice of the type of UHT plant. Source: The authors.

ASPECTS OF THE ARGUMENT	VALUES	CATEGORIES	Frequency
CONTENT	3		
	2	They use concepts but without explaining their meaning (indirect heating).	3
	1	They do not use concepts.	9
STRUCTURE	3		
	2	The one that uses indirect heating.	3
		The plant that produces a better-quality product.	3
	1	The one that allows to obtain a more natural coffee.	2
		The treatment depends on the type of coffee required	1
		Textual transcription of the guide.	5
FORMS OF DISCUSSION	3	- Proposes opposing ideas and supports them with concepts, data, and sources of information that go into detail and improve the argumentation in response to arguments that lack content or are incoherent. - Proposes concepts, data, and sources of information that go into detail and improve the argumentation.	0
	2	In response to diverse arguments, proposes complementary ideas, but without supporting them in sources of information or using inaccurate concepts.	0s
	1	The answer given by one of the members of the group is accepted, without going into detail.	12

Some examples of the responses are as follows:

> GC. “We would recommend the UHT type P, given that it indirectly transfers the heat through the product when it is being heated and when cooled it does not apply, so a natural product is obtained.”

The answer offered by Group C, corresponds to the transcription of the text that is presented in the guide, so there is no evidence of the association of the concepts learned. Other groups, like H, use general statements in their affirmation, such as pointing out that they choose the D type because it permits the conservation of the products properties and saves energy.

> GH. “We would advise Mario to choose UHT plant type D, because it has a direct method of heating and because it allows for a very high quality of the product. The

comprehensive steam injection and the instant filtering allows for very brief time spent in the zones of intense temperature."

Once the characteristics of the technological mechanisms are considered, Group D decided on a type I UHT plant, because of the advantages that it offers in regards to production and energy recovery.

Apart from that, the group adds that it has been one of the most broadly used mechanisms, and one of the most successful for a long time. The groups that chose a type P plant say they did it for environmental reasons.

Below, there is a discussion of one of the work groups of three students to choose the type of UHT plant.

94.Alberto: Well, that depends on what Mario wants to obtain from the coffee and on what he is looking for in
95. the coffee, I would believe that each type of heating will determine different characteristics for the
96.coffee. So, type I may give it more aroma, type P may give it a sweeter flavor, eliminate
97. the acidity, type D may give it other different characteristics, so we should talk
98. to Mario to know what it is that he expects from the coffee…thus, the science professional could
99. make a recommendation.
100.Antonio: in the case that it was to have a good quality product, and taking into account what
101.was said in the reading, I would recommend the UHT plant D, as what it mainly does
102.is to allow for a high quality of the product.
103.Alex: but we should see what type of coffee Mario has, the characteristics that this
104.coffee has, if this coffee works well with that plant or what treatment is best from the point of
105.view of the coffee, and what Alberto says and the point of view of what he wants. If we are
106.going to tell him, well I want my coffee to be mild, that it has these characteristics, and 107.these other characteristics, but that plant isn't suitable because it turns out that that plant cannot improve
108.this coffee.

The previous commentary responds to the setting of the situation presented in the sequence in regards to general characteristics, but it does not use the concepts given in the description of each type of plant. For example, it is assumed that each plant produces one type of coffee. In the same way, Antonio mentions that he would choose the plant that produces a coffee of high quality, without going into detail.

This reveals the difficulty the students have in weighing the advantages and disadvantages of the types of UHT plants presented and to see their viability as regards scientific concepts. Here the students could also discuss: aspects related to the environmental impact that these types of technological mechanisms produce, and relate them to energy efficiency.

In conclusion, it is demonstrated that the students did not have a good command of concepts related to physics and, for that same reason, they did not know how to apply them, given that in the guide the characteristics of the UHT plants were explained, but none of the groups took it into consideration in a conceptual way[1].

DISCUSSION AND CONCLUSIONS

[1] Bachelors in Natural Science and Environmental Education must have a command of concepts related to biology, chemistry and physics. However, the students admit to having conceptual difficulties in chemistry and physics.

From the introductory guide to the need of the study of argumentation in the teaching of the sciences, it is observed that the groups acknowledge as a fundamental aspect the possession of theoretical references to be able to make effective argumentative processes. This implies giving relevance to the use of information as a necessary condition for the advancement of scientific knowledge and the validation of the arguments presented, reaffirming what was stated by Sarda and Sanmartín (2000).

This helps to make clarifications between opinion and argumentation. There are also categories in which argumentation is valued beyond the merely informative aspect, which constitutes a process for the students of the Bachelor's Degree in Natural Science to reflect upon their learning processes that are implicit in aspects, such as the relationships professor-student, student-student, and student-knowledge.

As regards this, studies by Mercer and Littleton (2007), Alexander (2006), Chi (2009) mention that students learn more efficiently when there is active participation in the activity through debate, dialog, and interaction. This coincides with the contributions of Sampson and Walker (2012) in the respect that the social process of learning implies articulation between the concepts, the language, the representations, and the practices that define science as culture.

The participants indicate that argumentation is a necessary process in the validation of ideas, and they acknowledge that argumentation has allowed for the advance of scientific knowledge and to bring about reflections so as to contrast one's own opinions with theoretical fundaments. Similar aspects are pointed out by Dimopoulos and Koulaidis (2003), Oliveras *et al.* (2011), who affirm that argumentation permits a scientific and general literacy by linking social aspects in the study of scientific concepts.

The results presented in this study indicate that the students find it easier to answer the question about the effect of sodium bicarbonate in relation to that of trichloromethane. In the case of sodium bicarbonate, the students mentioned uses such as the preservation of coffee, neutralization of pH and reduction of solubility. In the second case, they mention characteristics like the generation of phases for decanting.

This aspect shows the need to question the use of all the reactive materials in the experimental practices, in order to procure a better association between what is observed, its meaning, and the use of scientific concepts. This aspect gives information about the comprehension of the scientific contents, reached by some of our students; in this case, some of the concepts are:chemical reactions, density, ionic and covalent compounds, and polarity.

This is in relation to the use of concepts that are specific to certain disciplines. However, the study carried out shows the need to strengthen the formation of future graduates in formal aspects so as to build arguments with a coherent and solid structure.

In spite of what is stated by Lunetta, Hofstein, and Clough (2007), that the practical work can be a learning experience where the students can understand concepts more easily, in this study it is observed that the lack of clarity as regards the concepts has an influence when there is confusion when it comes to the meaning of concepts in the experimental practice. For this reason, it is suggested that the quality processes of argumentation in the formation of teachers of scientific education are studied in depth.

It is acknowledged that the choice of the type of coffee is influenced by organoleptic characteristics. With respect to this, some students recognize the need to have a command of biochemical concepts to be able to evaluate the effects that each compound has in the body. Due to this situation, they decide on a type of coffee given the amount of caffeine. This segment allows them to recognize that the knowledge of the contents, or the lack of it, may distort the quality of the students' arguments. In the same way, no comments were made as regards the cost of each type of coffee (*Arabica and Robusta).* For example, in the market Arabica coffee tends to be more expensive as it has a milder and more pleasant flavor than

Robusta coffee, which has a more complex aroma, with lower acidity and caffeine (between 0.7 and 1.5%). For all of the above mentioned, Arabica coffee tends to be pricier.

In the results, it was observed that only 6 groups indicated that aromatic and volatile compounds are responsible for the aroma of coffee, yet a direct association of the volatile and aromatic concept with the type of enzyme reactions that take place for the aroma to arise is necessary. On the other hand, some of the reasons that are cataloged as the most distant ones to the question can be attributed to the industrial processes, the way the product is stored and the maturity of the fruits. Some reasons are mentioned, but they seem to hold no relation to the situation studied.

In this study, there were no arguments that described the type of aromatic compounds that are responsible for the aroma of coffee, such as thiazole and ethylphenol. In the same way, there are no established relationships with other types of processes like the effect of the temperature on the processes of lyophilization, or the effect of Maillard reactions and degradation, among others.

Actually, the commentaries do not allow us to link the effect of the roasting with the modification of the compounds and the properties of coffee, neither do they indicate the changes that the high temperatures produce in sugars, fats, proteins, non-proteic nitrogenized substances, and acids. With respect to this, Zuluaga (1990) says that the aroma and the flavor of coffee are developed during the roasting process. So, the composition of roast coffee depends on the level of roasting. In the coffee-roasting industry, that level is evaluated by measuring the light refraction of the grains or by visual inspection.

Finally, it is observed that the students present some difficulty in solidly justifying their affirmations based on scientific concepts. For this reason, it is necessary to make emphasis on the fact that argumentation goes beyond being an opinion and of being a merely informative action. It requires processes of association, deep knowledge of the topic, use of data, and theoretical sources that create spaces of uncertainty, which can be taken advantage of to formulate proposals for reflection within the pedagogic practices of the teacher trainers. It is about taking on the pedagogic practices from a transformational perspective and restructuring learning progressively toward the desired professional knowledge (Porlán & Martin, 1996).

In relation to the activities developed, it is possible to see that there is an absence of refutations in the conversations of the participants. So, it is essential to highlight how important refutations are in the scientific context, given that they constitute a way of improving theories of scientific knowledge and, from them, arguments are justified and questioned. The use of refutations constitutes a contribution to developing critical thinking in the students.

The results show how important it is that in the teaching and learning processes there is an emphasis on the assimilation of concepts demanded by each discipline. If not, the subjects would not have the theoretical references required to build and defend their argumentations in a solid way.

In the same way, the findings of this study seem to coincide with Penha (2012), who states that the development of argumentations in SSI spaces may lead to ideas getting too close to one another, which makes it difficult to have opposing perspectives. For this reason, it is necessary to use counterarguments that bring new aspects and other dimensions of analysis into discussion, to promote the participation of the students.

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