Analysis of the Argumentative Process of Students to a Social Dilemma related to Genetic Content

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ABSTRACT

Background: Studies on argumentation in science education have been devoted to the theoretical aspects of the quality of the arguments or the contributions and limitations of the proposals or learning environments, among others. **Objectives**: In particular, our study seeks to analyse the argumentative process of high school students as they experience an argumentation activity about the disciplinary content of genetics. **Design**: The intervention process was carried out through the course "Dialogues on Genetics," which lasted six weeks with a 16 hour-class workload. To achieve our objective, we analysed the data collected from Activity 8, entitled "Social dilemma related to consumption and production of genetically modified food." **Setting and Participants**: Twelve students between 15 and 18 years old, attending the 3rd grade of the High-School Integrated Vocational Course on Fishery Resources of IFRN - *Campus* Macau participated in this research. **Data collection and analysis**: The data collected consisted of audio and video recordings, which was organised through software ELAN, and the written record of the consensual argument each group prepared. **Results**: Our analysis of the dialogue data involved in the formulation of a consensual argument by a group of students identified three stages of the argumentative process, namely, (I) proposition, (II) negotiation, and (III) agreement. **Conclusions**: We evidenced that, following this three-part model, the argumentative process is repeated until the group reaches a consensus or withdraws from trying to persuade the peer with a counterclaim.

Keywords: Argumentative process; Argumentation assessment; Biology teaching; Genetics; Social dilemma.

Análise do Processo Argumentativo de Estudantes diante de um Dilema Social relacionado ao Conteúdo de Genética

RESUMO

Contexto: Estudos sobre argumentação no ensino de ciências têm sido dedicados aos aspectos teóricos da qualidade dos argumentos ou às contribuições e limitações das propostas ou ambientes de aprendizagem, entre outros. **Objetivos**: Em particular, nosso estudo procura analisar o

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processo argumentativo de estudantes do ensino médio, à medida que participam de uma atividade de argumentação sobre o conteúdo disciplinar de genética. **Design**: O processo de intervenção foi realizado por meio do curso "Diálogos sobre Genética", que durou seis semanas e teve 16 horas de aula; no entanto, para atingir nosso objetivo, analisamos os dados coletados para a Atividade 8, intitulada "Dilema social relacionado ao consumo e produção de alimentos geneticamente modificados". **Ambiente e Participantes**: Para este estudo, participaram 12 alunos, entre 15 e 18 anos, do 3º ano do Curso Técnico Integrado do Ensino Médio em Recursos Pesqueiros, no IFRN - *Campus* Macau. **Coleta e análise dos dados**: Os dados coletados consistiram na gravação de áudio e vídeo, organizada com o uso do software ELAN, e no registro escrito do argumento consensual preparado por cada grupo. **Resultados**: Analisando os dados de diálogo envolvidos na elaboração de um argumento consensual por um grupo de estudantes, nós identificamos três etapas do processo argumentativo, a saber: (I) proposição, (II) negociação e (III) acordo. **Conclusões**: Evidenciamos que, seguindo esse modelo de três partes, o processo argumentativo se repete até que o grupo chegue a um consenso ou desista de tentar persuadir o colega com uma opinião contrária.

Palavras-chave: processo argumentativo; avaliação da argumentação; ensino de biologia; genética; dilema social.

INTRODUCTION

In recent years, the emergence in research on argumentation in educational processes, ratified by educational policies in several countries, has given rise to different directions for research on this object of study. The changes in the research paradigm on science education directed the focus of teaching methodologies on the role of language and communication in the construction of scientific knowledge and for the collective cognitive process (Jiménez-Aleixandre, 2007). Deanna Kuhn (2010) claims that "the concept of science as argument, and the view that engaging in scientific argumentation should play a key role in science education, has become widely endorsed" (p. 810). The author, while discussing the epistemological results achieved in the behaviour of students during the implementation of argumentation in science classes, highlights the following: "learning to contain emotion, to listen, to think, to provide reasons to support claims, and to respond directly to what the other has said" (Kuhn, 2010, p. 819).

Jiménez-Aleixandre and Erduran (2007) define the process of argumentation as part of the discourse through which knowledge claims are individually or collaboratively constructed and evaluated in the light of empirical or theoretical evidence, the argument being its product (Sampson & Clark, 2008). Erduran, Ozdem, and Park (2015) stress the relevance of argumentation as a significant educational objective, situated as a critically important part of the scientific discourse process, in addition to the agreement that it should be taught in science classes as part of scientific investigation. The authors also highlight the importance of argumentation as a connection for scientific literacy or the achievement of socio-scientific and technological objectives.

In retrospect, Jiménez-Aleixandre, and Puig (2010) highlight the evaluation of knowledge in the light of available evidence as an inseparable element of the argument. This aspect is characterized as part of the basic competencies in science and technology

provided by the European Union (EU, 2006), besides being part of one of the three scientific competencies contained in the reports of the international assessment PISA - Programme for International Student Assessment (OECD, 2003), characterised as the scientific interpretation of data and evidence.

In the North American scenario, there are the benchmarks for science literacy, which were proposed by the American Association for the Advancement of Science - AAAS - in 1993 and are frequently updated. These benchmarks deal with the Nature of Science and draw attention to the need to present evidence to support a scientific claim through a logical argument, and highlight that theories that compete for acceptance directly depend on this structure to be considered valid in the scientific community (AAAS, 2017). Developed by the National Research Council (NRC), the Framework for K-12 Science Education identifies the ability to "participate in argumentation based on evidence" (NRC, 2012, p. 3) as one of eight scientific and engineering practices central for science teaching, as well as a recommendation for essential practices for the science and engineering curriculum.
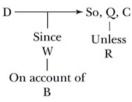
In Brazil, argumentative practice is characterised as the representation and communication competency - expressed in legal documents such as the National Curriculum Parameters (PCN) - associated with the critical position concerning science and technology themes (Brasil, 2006). The reference matrices of both ENEM (National High School Examination) and ENCCEJA (National Examination for the Certification of Youth and Adult Skills) lists "building argumentation" as a cognitive axis common to all areas of knowledge, whose competency lies in "relating information represented in different forms and knowledge available in concrete situations to build a consistent argument" (Brasil, 2015). The document also defines as one of the competencies of Languages and its Technologies "to confront opinions and points of view on different languages and their specific manifestations," in general, through the analysis of argumentative procedures and the recognition of argumentative strategies used in both dialogue and texts. Also, the construction of arguments appears in most of the skills listed for reference matrices in all areas of knowledge.

ARGUMENTATION ASSESSMENT IN SCIENCE CLASSES

Different studies have been carried out about the assessment of argumentation in science classes (Sampson & Clark, 2008). Most of them seek to examine the analytical tools used to assess the nature and quality of the students' argumentation in the classroom, highlighting the limitations and contributions of each one of them, defining the material variations between them, and attributing such variation to research questions and to theoretical perspectives considered by the authors when developing their works. It is not our intention to reproduce such works, but rather to point out a few examples that may be used as a basis for following up on the argumentative process of our intervention during the analysis of a relatively complex scientific topic.

Regarding the aspects related to the assessment of argumentation, the seminal work *The Uses of Argument*, by Stephen Toulmin (2003), is considered a milestone which, besides establishing a theoretical basis for this field of study, proposed an analytical model for argumentation developed to describe argumentation in practice (Figure 1). This model may be considered a useful tool for discourse analysis in situations of knowledge building in the classroom, and its main focus is to support claims whose validity directly depends on consistency and on being based on data and backing (Jiménez-Aleixandre & Erduran, 2015).

Figure 1
Toulmin's Argument Pattern. (Toulmin, 2003, p. 97)

Toulmin's Argument Pattern (TAP) consists of six elements. The three main ones are as follows: claim (C), which expresses an opinion regarding a particular issue which merits are sought; data (D), which is the set of information or facts we use as grounds for a claim; and warrant (W), characterized as a general statement serving as a bridge between data and the claim (Toulmin, 2003). The three secondary ones are as follows: backing (or basic knowledge) (B), which corresponds to one or more categorical statements about a particular fact related to the warrant; modal qualifier (Q), indicating the strength or certainty degree of conclusion attributed by the warrant; and rebuttal (R), referring to the circumstances that challenge the authority of the established argument (Toulmin, 2003).

In a review of different analytical tools to assess argumentation, Sampson and Clark (2008) identified three different topics, including the structure or complexity of the argument, the content of the argument, and the nature of the support. Among them, there were six analytical classifications to assess the strength of an argument based on the presence or lack of specific combinations of structural components established by Toulmin (2003): the structural complexity and the nature of the warrant to assess the quality of the argument instead of the content (Schwarz, Neuman, Gil & Ilya, 2003); assessment of the quality of the written arguments generated by students based on the content of the warrant (Zohar & Nemet, 2002); indication of the propositions found in an argument and classification based on the epistemic level (Kelly & Takao, 2002); and assessment of students' arguments in terms of field-dependent criteria, including conceptual and epistemological quality (Sandoval, 2003; Sandoval & Milwood, 2005).

In our study, we aim at focusing on the assessment of the verbal and written argumentative process related to a scientific topic involving a social and ethical dilemma. Thus, the choice (and adaptation) of the analytical tool should also be coherent with the object of study at stake. We present below a summary of different analytical tools developed to assess verbal and written arguments.

Example of an analytical tool to assess written arguments

Kelly and Takao (2002) designed an analytical tool to assess and monitor the evolution of written arguments, taking into account rhetorical studies on scientific writing and research on argumentation in science education. Like the abovementioned tools, this one was also based on studies on Toulmin's argument structure, considering both its potentials and limitations, especially regarding the codes which, according to the authors, can restrict the classification of the statements and, sometimes, present ambiguities (Kelly & Takao, 2002). The proposal for analysis in the quality of written argumentation consists of six epistemic levels, starting from the mere data representation, followed by the marshalling of such data and observation of trends, establishing references to theories, and the presentation of new knowledge through new interpretations for the phenomenon under discussion. Kelly, Regev, and Prothero (2007) later adapted this model, highlighting the considerations on the complex nature of the argument structure and maintaining the six epistemic levels related to the specific statements on the argument's disciplinary context. The model developed, called "scheme of argumentative structure and evaluation of criteria," presents the six most general previous levels, according to the following: lines of reasoning; data subscriptions; low inference statements; conclusions supported by previous statements; theoretical conclusion; and thesis.

Examples of analytical tools to assess verbal arguments

Erduran, Simon, and Osborne (2004) developed a tool with an analytical framework to assess the quality of the argument using TAP. The proposal seeks to classify the participants' dialogue in levels of complexity and quality based on the structure of the argument presented, as shown in Table 1:

This analytical framework was used in other studies (Simon, Erduran & Osborne, 2006) to analyse the argumentative discourse between students and teachers, identifying distinct pedagogical strategies for the promotion of argumentative skills, and assessing them.

Table 1

Analytical framework used to assess the quality of argumentation. (Erduran, Simon & Osborne, 2004, p. 928)

Level 1	Level 1 argumentation consists of arguments that are a simple claim versus a counterclaim or a claim versus a claim.
Level 2	Level 2 argumentation has arguments consisting of a claim versus a claim with either data, warrants, or backings, but do not contain any rebuttals.
Level 3	Level 3 argumentation has arguments with a series of claims or counterclaims with either data, warrants, or backings, with the occasional weak rebuttal.
Level 4	Level 4 argumentation shows arguments with a claim with a clearly identifiable rebuttal. Such an argument may have several claims and counterclaims.
Level 5	Level 5 argumentation displays an extended argument with more than one rebuttal.

The authors Sadler and Fowler (2006) developed a tool to assess the quality of argumentation related to socio-scientific issues. To do so, they used the adapted classification in levels of quality based on the TAP, which is similar to the tool used by Erduran, Simon, and Osborne (2004).

Based on the framework developed by Erduran, Simon, and Osborne (2004), Sadler and Fowler (2006) proposed a tool to assess the quality of argumentation related to socio-scientific issues. To do so, they adapted the classification in levels of quality of the justification of the argument, assigning a score from "0" to "4" to the excerpt of the discourse, and classifying it based on complexity. Namely: (0) when the claim has no support; (1) when the support has no grounds; (2) when the grounds presented for the support are simple; (3) when the claim is based on elaborated grounds; (4) when the support is based on elaborated grounds and counterclaims.

A similar proposal was developed by Sadler and Donnelly (2006) to operationalize high-quality argumentation, focusing on the structure of the argument and especially on the warrant developed to support the claims. The tool has three different criteria: position and rational analysis, which assesses the coherence and consistency of the support presented for the claim; multiple perspectives, assessed according to the ability to express multiple perspectives; and rebuttals, which assess the student's ability to challenge other students' grounds. Scores (from 0 to 2) are assigned to these criteria to assess the quality of the argument.

Examples of analytical tools through learning progressions

Berland and McNeill (2010) propose a learning progression for argumentation, taking into account the environment and the context within three dimensions: the instructional context, the argumentative product, and the argumentative process. The instructional context is responsible for supporting the students' involvement in the activity proposed, considering the complexity of the question asked, the size of the dataset available, the

adequacy of such data to the theme of choice, and the level of models and structures available for the organisation of the answer to the question. The argumentative product is defined in terms of written and verbal scientific argumentation, in which a statement of knowledge is justified through evidence. It may present four characteristics indicating quality: claim supported by scientific data, rebuttal used as counterclaims or alternative claims, the reasoning developed being projected to explain how the evidence supports the claim, and the elements of the argument being valid and sufficient. The argumentative process is based on social interactions and discourse movements, aiming at identifying four functions of statements during the discourse, that is, individuals state and defend their claims, question each other's claims and defences, assess each other's claims and defences, and, finally, review their claims and each other's.

In the same regard, Osborne *et al.* (2016) propose a learning progression for argumentation as means to assess the quality of argumentation in three stages or levels that represent the cognitive load intrinsic to the progressive complexity in written or verbal argumentation. The authors consider a combination of content, procedural knowledge and epistemic knowledge, and the ability to use proper information in the support. Thus, the analytical tool considers "level 0" for the construction and identification of claims and the provision and identification of evidence, and no explicit connections between claim and evidence are required; "level 1" refers to the presentation of a logical, explicit connection between claim and evidence through a warrant, which requires comprehension of the relation between these two elements of an argument; "level 2" requires students to build, compare, and criticise two or more structures of arguments. So, according to the authors, the arguments developed by following the structure of items in higher levels represent a more difficult cognitive load for students to show argumentative competence, accompanying the idea that operationalises the argument as consisting of construction and criticism, in which, if the student manages to coordinate the elements of their own argument, the practice may progress toward a more abstract task, such as assessing and criticising a peer's argument.

OBJECTIVE

To analyse the argumentative process of students during a scientific argumentation practice.

METHODOLOGY

The intervention process was carried out through the course "Dialogues on Genetics," which lasted six weeks, with a 16 hour-class workload, and used an original teaching material (Silva & Silva, 2018). We consider that there is no predetermined and mandatory order in which an argument must be developed or presented. We understand that some models or patterns may be used as tools to identify basic elements in an

argument better, thus, we use different theoretical references as bases, as described in Table 2.

Altogether, 12 activities were developed; however, to achieve our objective, we have analysed activity 8 (Table 2), entitled "Social dilemma related to consumption and production of genetically modified food." It consisted of reading a text with information about the earthquake that occurred in Haiti in 2010 and the following humanitarian assistance from several countries and companies, including Monsanto, which offered a partnership with the donation of genetically modified seeds to modernise the agricultural production in the country. After reading, the students were told to take a stand about which would be the best decision for the country: whether accepting the donation of the seeds through the partnership with the Monsanto company. As complementary material, there was information about the differences between the two types of seed, regular and genetically modified, and a company video explaining its mission and the areas in which it operates.

Table 2
Structure of the activities and steps of the intervention

Step	Theoretical Basis	Argumentative Skills Expected	Genetics Content
1	Structure and elements of an argument. (Toulmin, 2003)	1st Stage: To claim in writing.	Activity 1: Cell division, DNA replication, and mutations.
		2nd Stage: To develop an argument based on Toulmin's Pattern.	Activity 2: Concept of genes, DNA transcription and translation, and protein folding.
		3rd Stage: Argumentation in pairs by negotiating the data to present a claim.	Activity 3: DNA, genes, genome, and chromosomes.
		4th Stage: To gather data and to back through research to support a claim.	Activity 4: Human Genome Project.
2	Argumentative sequences and counterarguments. (Sampson & Clark, 2011; Osborne *et al.*, 2016)	5th Stage: Argumentative structure simplified into a claim, warrant, and Evidence to support verbal argumentation.	Activity 5: Genetic disorders.
		6th Stage: Verbal argumentation by using arguments and counterarguments.	Activity 6: Recombinant DNA and molecular cloning.
		7th Stage: Comparison between a well-structured argument and an argument with no structure.	Activity 7: Genetically Modified Organisms (GMO) and transgenic crops.
3	*Opinion debate and persuasive attempt. (Sampson & Clark, 2011; Osborne et al., 2016)*	*8th Stage: Argumentative dialogue and persuasion.*	*Activity 8: Social dilemma related to the consumption and production of genetically modified food.**
		9th Stage: Argumentation in informal situations.	Activity 9: Ethical dilemma related to the genetic modification of humans.

Step	Theoretical Basis	Argumentative Skills Expected	Genetics Content
4	Argumentation in the scientific community (Kelly & Takao, 2002; Kelly, Regev, & Prothero, 2006)	10th Stage: Analysis of the argumentative structure of scientific papers.	Activity 10: Analysis of scientific papers related to Genetics.
		11th Stage: Preparation of a scientific argumentative essay (Content relevance).	Activity 11: Discussions based on the theme "Genetics and..."
		12th Stage: Presentation of a scientific work to the academic community (Opinion).	Activity 12: Written text production on Genetics.

Consistent with the perspective proposed by Jiménez-Aleixandre (2007), which defines argumentation as an assessment of knowledge and considers it the central axis to develop a learning environment, the activity was developed in two stages:

(1) Promotion of the negotiation of the different points of view about a socio-scientific topic, initially in small groups; and

(2) Written preparation of a consensual argument of the group, according to Toulmin's elements.

The first stage aimed at promoting dialogue and negotiation of common and different points of view; the second one focused on writing, following a model that presented a clear claim, based on valid evidence, connected by well-articulated support. These stages explored aspects related to communication during collaboration in a dialogical approach to re-elaborating scientific statements based on the models provided by the teacher.

As research participants, we chose 12 students between 15 and 18 years old, who attended the 3rd grade of the High-School-Integrated Vocational Course on Fishery Resources of IFRN – *Campus* Macau[1].

Data were collected and organised through audio and video through the software ELAN and the written record of the consensual argument prepared by each group. For the transcript, we used the elements of the argument proposed by Osborne *et al.* (2016), adapted from Toulmin, in which we have: "Claim," which refers to the answer to a question; "Evidence," corresponding to scientific facts or data supporting the Claim; and "Warrant," which logically articulates Evidence selected to support the Claim.

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[1] At the end of 2016 and the beginning of 2017, when this research was being carried out, the Institution was in an internal debate on the insertion of requests to the Research Ethics Committee - REC - in the area of Science Education. In addition, the research location was returning from a period of occupation in schools, result from an academic-political movement against the High School Reform Project imposed by the Federal Government. Thus, as a way of safeguarding the ethical principles of this research, we proceeded with the elaboration of the Free and Informed Consent Term (ICF), [model submitted as a supplementary document] and collected the signature from all participating students and, in certain cases, from their legal guardians. We, therefore, exempt the journal *Acta Scientiae* for any consequences in due, including full assistance and possible compensation for any damage resulting to any of the research participants, in accordance with Resolution No. 510, of April 7, 2016, of the National Council of Health.

For the analysis of the learning progression, we used the analytical tools that we describe below.

Analytical tools to assess the argumentative process

To analyse the complexity of the argumentative process, we seek support in two analytical tools (or devices): one, developed by Berland and McNeill (2010) to identify the argumentative functions used by the students during the discourse, and the other, developed for the argument levels of Osborne *et al*. (2016).

For the argument levels, the tool developed by Osborne *et al*. (2016) considers that the initial action of proposing a well-supported argument may be followed by criticism, requiring cognitive operations of more complex analysis to identify the elements of the argument and assess their validity to further prepare a counterargument. The progression ranges from "level 0," with no articulation of a full argument, to "level 2," with the comparison and criticism of the arguments prepared. Each level has four sub-levels, from "a" to "d," according to the complexity of each argument prepared, which are presented in turns, representing construction and criticism, in which the ability to criticise is considered more advanced, despite presenting the same level of complexity as construction. The proposal for progression between the levels of arguments for this tool is presented in Table 3 below.

Table 3
A proposed learning progression for scientific argumentation. (Adapted from Osborne *et al*., 2016, p. 828)

Level	Constructing	Critiquing	Description
0			no evidence of ease with argumentation.
0a	constructing a claim		student states a relevant claim.
0b		identifying a claim	student identifies another person's claim.
0c	providing evidence		student supports a claim with a piece of evidence.
0d		identifying evidence	student identifies another person's piece of evidence.
1a	constructing a warrant		student constructs an explicit warrant that links their claim to evidence.
1b		identifying warrant	student identifies the warrant provided by another person.
1c	constructing a complete argument		student makes a claim, selects evidence that supports that claim, and constructs a synthesis between the claim and the warrant.
1d	providing an alternative counter argument		student offers a counterargument as a way of rebutting another person's claim.

Level	Constructing	Critiquing	Description
2a	Providing a counter-critique		Student critiques another's argument. Fully explicates the claim that the argument is flawed and justification for why that argument is flawed.
2b	Constructing a one-sided comparative argument		Student makes an evaluative judgment about the merits of two competing arguments and makes an explicit argument for the value of one argument. No warrant for why the other argument is weaker.
2c		Providing a two-sided comparative argument	Student makes an evaluative judgment about two competing arguments and makes an explicit argument for why one argument is stronger and why the other is weaker.
2d	Constructing a counterclaim with justification		Student compares and contrasts two competing arguments, and constructs a new argument in which they justify why it is superior to previous arguments.

The key functions of the argumentative process, in which the movement of the discourse begins with a statement and the defence of claims. This action leads to questions that may provide new data and reinforce the argument itself or undermine the contrary argument, followed by mutual assessment of the claims and defences elected, culminating with the review of the structured arguments, as represented in Figure 2.

Figure 2
Key enunciation functions of the argumentative process. (Adapted from Berland and McNeill, 2010, page 776)

RESULTS

The students were divided into three groups (A, B, and C), each one with 4 students, and the stages of the analyses of the argumentative process were arranged in tables.

Group A: the process and the product of argumentation

During the interaction, the group tried to validate a claim and then the evidence. They discuss claims and alternative explanations. There are opposing points of view, where evidence of the seed yield is presented, as shown in the table below:

Table 4
Transcript of the dialogue between students in Group A

Student	Argumentative Process (Transcript)	Classification	Level
Sandra	We need to weight the benefits, "the pros and cons." Then what's going to happen? Here, the only "pros" of the genetically modified seeds are that they are more resistant [*Evidence*] …	Statement	0c
Tainá	We also must consider that the conventional seeds are more expensive [*Evidence*].	Statement	0c
Sandra	No [*Claim*]. The "con" is that it is more expensive [*Evidence*]. The "pros" are in favour.	Statement and Defence	0a, 0c
Tainá	But they (genetically modified seeds) yield twice as much as the conventional ones [*Evidence*].	Statement	0c
Sandra	But if we weight that, even if they yield twice as much [*Evidence*], it doesn't matter, because they are going to need to buy more seeds from Monsanto [*Warrant*]. They are going to have to spend this money again and again [*Claim*].	Statement and Defence	1c

Afterwards, Sandra,[2] upon defending her point of view, presents a "level 1a" argument structure, requiring a greater cognitive load both in the proposal and in the understanding, so that Tainá only identifies the claim through a question, trying to understand better the argument presented. In other words, while Sandra assesses a piece of Evidence, possibly contrary to her own claim, Tainá considers a new hypothesis based on a warrant, which is promptly evaluated and criticised by Sandra with a more complex "level 1d" argument.

Table 5
Transcript of the dialogue between students in Group A

Student	Argumentative Process (Transcript)	Classification	Level
Sandra	The regular crops are vulnerable to pests, insect attacks, and such [*Evidence*], but, with caution… if you take good care... it's really a matter of caution.	Statement	0c
Tainá	But if they were attacked, the farmers would lose everything [*Warrant*].	Statement and Defence	1a

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[2] Fictional names

Student	Argumentative Process (Transcript)	Classification	Level
Sandra	But just like the regular ones are (vulnerable), the genetically modified ones are (vulnerable) too [*Claim*]. The thing is they are a little more resistant [*Evidence*], but if you're not cautious pests may attack them too [*Warrant*].	Evaluation	1d

Based on evidence about the use of pesticides in the crops, the group follows Sandra's point of view through a concept about agricultural pesticides, somehow, grounded on common sense, hence, being at level 0 (a, b, c).
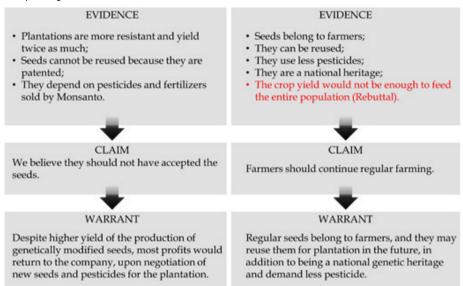
Table 6

Transcript of the dialogue between students in Group A

Student	Argumentative Process (Transcript)	Classification	Level
Sandra	Oh! Another good thing: "they use a smaller amount of pesticides" [*Evidence*]. (...) That's it, because pesticides are extremely… many pesticides are harmful to the crops [*Evidence*] And they can cause diseases in the people consuming them [*Evidence*]. In addition to losing the whole crop [*Evidence*]. Because, in many crops, the plants grow with a lot of diseases because of pesticides [*Evidence*].	Statement	0c
Tainá	So, our claim is that they shouldn't have accepted [*Claim*]? (silence) Right?!	Question	0b
Sandra	Yes… no! Let's say "we do not think that they should have accepted the seeds" [*Claim*].	Statement	0a
Tainá	Wouldn't it be better to say that they should continue using the conventional seeds [*Claim*]?	Question	0b

When revising the argument prepared, negotiating and discussing and leading to "level 1c", the students list evidence (pro and con) of regular seeds. A topic that stands out, despite not being the object of a study, is the fact that the use of evidence about pesticides is based on conceptual error. The scheme below presents Group A's arguments.

Figure 3
Group A's Arguments

EVIDENCE	EVIDENCE
• Plantations are more resistant and yield twice as much; • Seeds cannot be reused because they are patented; • They depend on pesticides and fertilizers sold by Monsanto.	• Seeds belong to farmers; • They can be reused; • They use less pesticides; • They are a national heritage; • The crop yield would not be enough to feed the entire population (Rebuttal).
CLAIM We believe they should not have accepted the seeds.	**CLAIM** Farmers should continue regular farming.
WARRANT Despite higher yield of the production of genetically modified seeds, most profits would return to the company, upon negotiation of new seeds and pesticides for the plantation.	**WARRANT** Regular seeds belong to farmers, and they may reuse them for plantation in the future, in addition to being a national genetic heritage and demand less pesticide.

Group B: the process and the product of argumentation

The dialogue with Group B was focused on evidence presented in the text regarding the performance of the production of seeds and the possibility of enhancing the feeding of the population. In this interaction, it is possible to observe a well-articulated warrant with "level 1a". In this process, students try to identify the evidence presented, questioning, and exposing new evidence, but they are unable to reach a consensus on the claim (Table 7):

Table 7
Transcript of the dialogue between students in Group B

Student	Argumentative Process (Transcript)	Classification	Level
Kelvin	We need to take the evidence into account. Look at this: "(regular seeds) would not effectively meet the feeding demand of the population" [*Evidence*] This means that these other (genetically modified) seeds would feed more people. [*Warrant*]	Statement and Defence	0c, 1a
Lívia	Yeah, I know. But what if it goes wrong? Haiti is a poor country! [*Evidence*] We need to reach a consensus about this…	Question and Defence	0d, 0c
Kelvin	We cannot rush to the claim. First, we need to take into account the evidence in the text.		

The fact that the students did not reach a consensus (under the teacher's guidance) reminded them of strategies used in the identification of Evidence and texts with scientific content. This process of weighing environmental issues related to this decision making takes arguments to a higher level (Table 8).

Table 8
Transcript of the dialogue between students in Group B

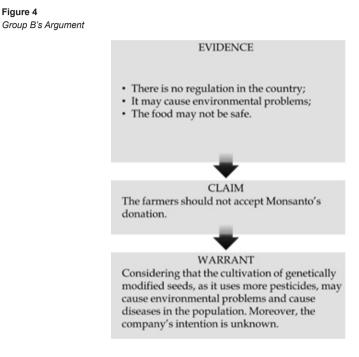| Student	Argumentative Process (Transcript)	Classification	Level
Kelvin	There is also the environmental issue, right?! Because they need to preserve soil resources, and higher use of pesticides can harm future plantations. [*Warrant*]	Statement and Defence	1a
Camila	That's true, if a plantation uses a lot of pesticides, I don't know how it can be beneficial to anyone. [*Warrant*] I wonder if this crop (with genetically modified seeds) is really going to be bigger than the regular one (with regular seeds).	Assessment	1b
Kelvin	Yes, production is higher! [*Evidence*]	Defence	0c
Lívia	But what if something happens? Let's write this (the environment issue) down as evidence.	Question	0d

By questioning the production of genetically modified seeds and rereading texts, students started debating the advantages of using the seeds and the company's patent. This discourse interaction process between students is maintained at level 0 (a, c, d). They reviewed the evidence listed and Kelvin presented a counterargument, claiming that farmers should accept the company's donation. This position was not accepted by one of the students, who ended the discussion.

Table 9
Transcript of the dialogue between students in Group B

Student	Argumentative Process (Transcript)	Classification	Level
Kelvin	The genetically modified seeds yield more than regular seeds [*Evidence*]. Additionally, the (genetically modified) plants are more resistant to the pesticide used, and they have a defense against the attack of pests [*Evidence*]. The problem is that the soil would still be contaminated with the pesticides used [*Warrant*]. But it's the only way to feed the Haitian population [*Claim*].	Assessment	1d
Clara	Guys, I don't agree! And I'll keep saying that I don't agree [*Claim*]! Of course, the country is going through problems, and these problems will not be solved overnight. And it (the country) is definitely "working" with donations [*Evidence*]. These (regular) seeds that they have, they will be able to continue planting them and feeding the population in the future [*Evidence*].	Statement and Defence	0a, 0c
Kelvin	But the regular crops will not be enough to feed everyone [*Warrant*]. They will starve [*Claim*].	Statement and Defence	1a, 0a

The group continues choosing pieces of evidence to support the claim of not accepting the donation of the seeds and support the written argument. It is noteworthy that some students of the group, to convince the others of their argument (decision), used inappropriate reasoning strategies and rhetorical tools.

EVIDENCE

- There is no regulation in the country;
- It may cause environmental problems;
- The food may not be safe.

CLAIM
The farmers should not accept Monsanto's donation.

WARRANT
Considering that the cultivation of genetically modified seeds, as it uses more pesticides, may cause environmental problems and cause diseases in the population. Moreover, the company's intention is unknown.

Group C: the process and the product of argumentation

Group C's dialogue focuses on the preparation of questions and, at the same time, on potential answers. The first evidences discussed are related to the company's intention and the probability of profit, suggesting the possibility that farmers would end up completely dependent on the partnership. In the discourse interaction with the group, Clau proposes that "*they (the company) only wanted the profits* (Claim)! *The owners want to pretend good will to make them (farmers) interested in the product (genetically modified seeds), so, since they (farmers) cannot reuse the seeds produced, they (farmers) would have to buy more* (Warrant)", reaching level 1a.

The group reached a consensus and reviewed evidence, reaching level 1c, debating the coordination of the argument elements and potential counterarguments. Potential rebuttals discussed by the group led to the re-elaboration of the warrant, considering the companies' profit.

We call attention to this group and to the fact that, during the process, the student Dante assesses and criticises the initial consensus and establishes a new position, reaching more complex levels, as shown in Table 11.

Table 10

Transcript of the dialogue between students in Group C

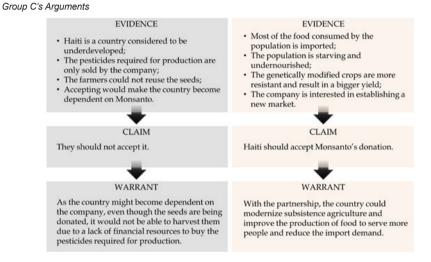| Student	Argumentative Process (Transcript)	Classification	Level
Clau	This... look at this! This part here (referring to an excerpt) about the price. It is as if the company wanted to create a mean to convince the country to accept the partnership [*Warrant*]. Look: "a portion of these seeds would be immediately donated to farmers, and the rest would be stocked by the government for resale at symbolic prices" [*Evidence*] they would sell them for a cheaper price [*Evidence*].	Statement and Defence	1a, 0c
Mario	Yes. But this would only happen to the seeds. [*Warrant*]	Assessment	1b
Clau	Exactly, and I think the seeds would only be cheap at first; after everyone bought them, they would raise the prices. [*Warrant*]	Statement and Defence	1a

Table 11

Transcript of the dialogue between students in Group C

Student	Argumentative Process (Transcript)	Classification	Level
Dante	Yes, but this is capitalism [*Claim*]. They only need to acquire a new debt to purchase the seeds and pesticides to start producing. [*Warrant*]	Statement and Defence	0a, 1a
Mario	Okay. But explain why. Tell me what your warrant is.	Question	0b
Dante	I told you, a new debt. [*Evidence*]	Defence	0c
Mario	But you have to take into account what is in the text.	Question	0d
Dante	Look, I know it's complicated. But we need to take into account that the country has suffered this natural catastrophe. [*Evidence*]. Would it be good if they continued producing with regular seeds? Yes! [*Claim*] But this will take longer, and they do not have enough seeds [*Warrant*]… and they have no time to get it together. [*Evidence*] They will need any help they can get, and quickly. [*Evidence*]. You tell me they have no money, but this is what external debt is for [*Claim*]. They will have to offer something as a guarantee, so the debt is paid in instalments. [*Warrant*].	Assessment	2b
Mario	But they already have nothing. [*Evidence*].	Defence	0c
Clau	So, you're suggesting they incur more debt?	Question	0b
Dante	Of course! [*Claim*] You must understand this is the logic of the market. [*Evidence*]	Statement and Defence	0a, 0c
Pedro	But these seeds are only for feeding [*Claim*], they are not very important. [*Evidence*]	Statement and Defence	0a, 0c

Student	Argumentative Process (Transcript)	Classification	Level
Dante	This is serious. They were already famished because most food is imported. [*Evidence*] So, the situation only got worse. They will need a quick solution. [*Claim*] They need to think of something that quickly solves the situation and is potentially profitable, because this is what capitalism wants. [*Warrant*]	Statement and Defence	1c

The debate continues and the group attempts to weigh each piece of evidence that has already been listed and refute the new claim supported in new pieces of evidence and assumptions from a social and economic point of view. They do not reach a consensus and decide to present both arguments separately.

Figure 5
Group C's Arguments

DISCUSSION AND CONCLUSION

In this discourse interaction, it is possible to note a relation between the level of an argument in the discourse of one student and the following argumentative dialogue. Generally, even if a group presents favourable trends about a given point of view, the consensus happens when one of the participants presents a more complex structure. Based on the combination of the tools presented by Berland and McNeill (2010) and Osborne *et al*. (2016), we identify three stages during the argumentative process, according to Figure 6.

The mapping made by codifying and analysing the data may be evidence that during the preparation of a consensual argument by a group of students, based on a task for them

to make decisions about a social dilemma, the argumentative process tends to go through different stages, which we call **(I) proposition**, **(II) negotiation**, and **(III) agreement**.

During **Stage I – Proposition**, the discourse tends to consist of statements followed by questions and defences of claims, alternating between "levels 0a and 0d," with claims and pieces of evidence being presented among the participants. Even though this stage consists of a less elaborated level of argumentation within the process, this moment is a decisive stage in the improvement of the argument grounds to be developed.

Stage II – Negotiation begins with the introduction of a statement followed by a defence with at least one well-formulated warrant, starting at "level 1a." During assessment of the argument, the students identify the warrant stated, reaching "level 1b." The assessment continues until one complete "level 1c" argument is developed, with a clear claim grounded on evidence to support it, and a warrant that articulates the knowledge contained in the two elements. In case a student has a simple or complex counter argument of a "level higher than 1d" criticising it, the assessment process restarts.

Stage III – Agreement begins with the revision process and requires at least "level 1c," with the preparation of a complete argument by the group, with the revision to analyse whether the elements are sufficient to support it. At this stage, usually, the discussion goes in the direction of a consensual claim, and a new argument is only assessed if it has a structure of a "level higher than 2a," considering the need for it to justify why the argument is weak and which are the weaknesses of the warrant presented.
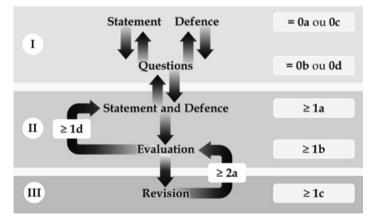
Figure 6
Mapping of the Argumentative Process

Thus, we evidenced that the argumentation process in which a specific group aims to reach a consensus and present a joint opinion, as we had planned in the activity, follows the path proposed by Berland and McNeill (2010), in which students state and defend their claims, question each other, and assess the adequacy of the propositions to meet the

statements of the matter proposed. As verified during the data analysis, it was possible to notice that this movement in discourse repeats itself until the group reaches a consensus or withdraws from trying to persuade the peer with a counterclaim.

In short, during the preparation of the consensual argument, the students' argumentation process tends to remain in **Stages I** and **II**, which reflects the importance of proposition and negotiation of claims or perspectives, until the structure expected for **Stage III** is reached.

We emphasise that the presentation of a complex, high-level argument will not necessarily convince others in a discourse; still, it will be more likely to convince a peer about an opinion presented. We also verified that other aspects outside the scope of our research and outside of the spectrum of analysis of these tools may have influenced both positively and negatively the results discussed here.

AUTHORS' CONTRIBUTIONS STATEMENTS

M.L.M.S. and M.G.L.S. conceived the idea of the article. M.L.M.S. researched papers published about this study object, designed, and implemented the intervention, collected data, and, together with M.G.L.S., organised, analysed, and participated in the discussion of the results. Both reviewed and approved the final version of the work.

DATA AVAILABILITY STATEMENT

Data collected and analysed during the current study are available from the corresponding author, M.L.M.S., on reasonable request and at the authors' discretion.

REFERENCES

AAAS. American Association for the Advancement of Science. (2017) *Benchmarks for science literacy*. http://www.project2061.org/publications/bsl/online/index.php

Berland, L. K., & McNeill, K. L. (2010). A Learning Progression for Scientific Argumentation: Understanding Student Work and Designing Supportive Instructional Contexts. *Science Education*, 94, 765-793.

Brasil. Ministério da Educação. (2015) Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira – INEP: *Matrizes de Referência*. http://portal.inep.gov.br/matriz-de-referencia

Brasil. Ministério da Educação. (2006) *Orientações Curriculares para o Ensino Médio*: ciências da natureza, matemática e suas tecnologias, 2. SEB.

Erduran, S., Ozdem, Y., & Park. J. (2015) Research trends on argumentation in science education: a journal content analysis from 1998–2014. *International Journal of STEM Education*, *2*(5).

Erduran, S., Simon, S., & Osborne, J. (2004). TAPping into argumentation: Developments in the application of Toulmin's argument pattern for studying science discourse. *Science Education*, *88*(6), 915-933.

Jiménez-Aleixandre, M. P. (2007). Designing Argumentation Learning Environments. In: Erduran, S.; Jiménez-Aleixandre, M. P. (Eds.), *Argumentation in science education: perspectives from classroom-based research* (pp. 91-115). Springer.

Jiménez-Aleixandre, M. P., & Erduran, S. (2015). Argumentation. In: Gunstone, R. (Ed.) *Encyclopedia of Science Education* (pp. 54-59). Springer.

Jiménez-Aleixandre, M. P., & Puig, B. (2010). Argumentación y evaluación de explicaciones causales en ciencias: el caso de la inteligencia. *Alambique: Didáctica de las Ciencias Experimentales*, 63, 11-18.

Kelly, G. J., Regev, K., & Prothero, W. (2007). Analysis of Lines of Reasoning in Written Argumentation. In: Erduran, S.; Jiménez-Aleixandre, M. P. (Eds.), *Argumentation in science education: perspectives from classroom-based research* (pp. 137-157). Springer.

Kelly, G. J.; Takao, A. (2002). Epistemic levels in argument: An analysis of university oceanography students' use of evidence in writing. *Science Education*, *86*(3), 314-342.

Kuhn, D. (2010) Teaching and Learning Science as Argument. *Science Education*, 94, 810-824.

Sadler, T. D., & Fowler, S. R. (2006). A threshold model of content knowledge transfer for socioscientific argumentation. *Science Education*, 90, 986-1004.

NRC - National Research Council. (2012). *A Framework for K-12 Science Education*: Practices, Crosscutting Concepts, and Core Ideas. Washington, DC.: Committee on a Conceptual Framework for New K-12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education.

Sadler, T. D., & Donnelly, L. A. (2006). Socioscientific argumentation: the effects of content knowledge and morality. *International Journal of Science Education*, *28*(12), 1463-1488.

Sampson, V., & Clark, D. B. (2008). Assessment of the Ways Students Generate Arguments in Science Education: Current Perspectives and Recommendations for Future Directions. *Science Education*, 92, 447-472.

Simon, S.; Erduran, S.; Osborne, J. (2006). Learning to teach argumentation: research and development in the science classroom. *International Journal of Science Education*, *28*(2-3), 235-260.

Toulmin, S. E. (2003). *The Uses of Argument*. (2nd ed.). Cambridge University Press.

Sandoval, W. A. Conceptual and epistemic aspects of students' scientific explanations. *Journal of the Learning Sciences*, *12*(1), 5-51.

Sandoval, W. A.; Millwood, K. (2005). The quality of students' use of evidence in written scientific explanations. *Cognition and Instruction*, *23*(1), 23-55.

Sampson, V., Enderle, P. J., & Walker, J. P. (2011). The development and validation of the Assessment of Scientific Argumentation in the Classroom (ASAC) observation protocol: A tool for evaluating how students participate in scientific argumentation. In: Kline, M. (Ed.), *Perspectives in Scientific Argumentation: Theory, Practice and Research* (pp. 235-264). Springer.

Schwarz, B. B., Neuman, Y., Gil, J., & Ilya, M. (2003). Construction of collective and individual knowledge in argumentative activity. *Journal of the Learning Sciences*, *12*(2), 219-256.

Silva, M. L. M., & Silva, M. G. L. (2018). *DNA: Diálogo, Genética e Argumentação*. (1ª ed.). Editora IFRN.

OECD - Organization for Economic Cooperation and Development. (2003). *PISA Assessment Framework*—Mathematics, reading, science and problem solving knowledge and skills.

Osborne, J., Henderson, J. B., MacPherson, A., Szu, E., Wild, A., & Yao, S. (2016). The Development and validation of a learning progression for argumentation in Science. *Journal of Research in Science Teaching*, 53, 821-846.

Zohar, A; Nemet, F. (2002). Fostering Students' Knowledge and Argumentation Skills Through Dilemmas in Human Genetics. *Journal of Research in Science Teaching*, *39*(1), 35-62.