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Critical Thinking in Development: An Analysis of Interactions in a Socioscientific Debate

Pensamento Crítico em Desenvolvimento: Uma Análise de Interações em um Debate Sociocientífico

Pensamiento Crítico en el Desarrollo: Un Análisis de las Interacciones en un Debate Sociocientífico

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Abstract

Critical thinking (CT) is a goal pursued by the field of science education in the 21st century. However, CT often appears as a cometic criticism or something without a deeper understanding of the issues analyzed. In this paper, we mobilize references capable of giving visibility to CT components under development in science lessons interactions. Based on Ethnography in Education, we followed science lessons of a class over 8th and 9th grades of Elementary School and selected discursive interactions for CT analysis, during the debate on a controversial issue. Instructional contexts experienced by the classroom became resources for students to position themselves, understanding the relevance of using and evaluating scientific evidence and evidence from other domains, in addition to the collaborative role in the construction of democratic positions. These results align with paths that have been thought of by the Science Education field for a post-truth era.

Keywords: critical thinking, science learning, discursive interactions

Resumo

O pensamento crítico (PC) é um objetivo almejado pela área de Educação em Ciências no século XXI. Todavia, o PC aparece muitas vezes como um criticismo cosmético ou sem um aprofundamento das questões analisadas. Neste artigo mobilizamos referenciais capazes de dar visibilidade a componentes do PC em desenvolvimento nas interações em aulas de ciências. Baseados na Etnografia em Educação, acompanhamos as aulas de ciências de uma turma no 8° e 9º ano do Ensino Fundamental e selecionamos interações discursivas para análise do PC durante um debate sobre uma questão controversa. Contextos instrucionais vivenciados na turma se tornaram recursos para que os estudantes pudessem se posicionar, compreendendo a relevância de se usar e avaliar evidências científicas e de outros domínios, além do papel colaborativo na construção de posicionamentos democráticos. Esses resultados se alinham a caminhos que têm sido pensados pela área de Educação em Ciências para uma era de pós-verdade.

Palavras-chave: pensamento crítico, aprendizagem de ciências, interações discursivas

Resumen

El pensamiento crítico (PC) es un objetivo perseguido por el campo de la enseñanza de las ciencias en el siglo XXI. Sin embargo, el PC muchas veces aparece como crítica cosmética o sin una comprensión más profunda de los temas analizados. En este artículo movilizamos referencias capaces de dar visibilidad a los componentes de PC en desarrollo en las interacciones en las clases de ciencias. Con

base en Etnografía en Educación, seguimos clases de ciencias en una clase de 8º y 9º año de Educación Primaria y seleccionamos interacciones discursivas para análisis de PC, durante el debate sobre un tema controvertido. Los contextos instruccionales vividos en la clase se convirtieron en recursos para que los estudiantes se posicionaran, entendiendo la relevancia de utilizar y evaluar evidencia científica y de otros dominios, además del rol colaborativo en la construcción de posiciones democráticas. Estos resultados se alinean con caminos que han sido considerados por el área de Educación en Ciencias para una era de posverdad.

Palabras clave: pensamiento crítico, aprendizaje de las ciencias, interacciones discursivas

Introduction

The growing spread of fake news, the decline in public trust in science, and the popularization of the Internet and social media are some of the issues that mark social life in the 21st century. Every day, we are bombarded with information that can be accessed from the palm of our hand. Misinformation (false content), disinformation (content designed to cause harm and gain), and misinformation (true information disseminated with the intention of causing harm) (Wardle & Derakhshan, 2018) make up a true "information arms race" (Sinatra & Lombardine, 2020, p. 1). In many cases, this information is directly related to science and circulates among students (Allchin et al., 2024).

Along with these phenomena, we are dealing with complex issues that affect contemporary society at a global level, such as climate change and the Covid-19 pandemic. In this context, educators and researchers have reflected on and questioned the role of science teaching. There is a consensus today in the field of Science Education research that science teaching should provide ways of thinking and taking a critical stance on these issues (Osborne et al., 2022; Silva & Sasseron, 2021). However, thinking critically at school often appears as "cosmetic criticality" (Bacon, 2018). In other words, students are led to instinctive scepticism without theoretical clarity or in-depth analysis of the issues analysed, generating more damage than formative benefits.

School science should provide opportunities for students to become "critical consumers and producers of science from which to support their agency in a changing world" (Puig et al., 2023, p. 4). This means using science as an important source of information and using its ways of constructing knowledge as a relevant way of conceiving positions in the contemporary world, even with its limitations. Such demands appear in queue with teaching proposals aimed at developing critical thinking (CT) (Jiménez-Aleixandre & Puig, 2022).

Although there is no consensus on the meaning of CT (Kuhn, 2019), Jiménez-Aleixandre and Puig (2022) state that the term is related to two central aspects in Science Education: (1) CT is related to assessment practices or evidence-based judgement and; (2) CT has a dispositional dimension, that is, it depends on the propensity of the one

who thinks. In Brazil, an important part of the work on CT has focused on pedagogical proposals capable of promoting it among students (Costa et al., 2021). However, the review by Costa et al. (2019) indicates that research analysing CT in the context of Basic Education is scarce. Thus, this work contributes to the national literature by presenting analyses that point out how the components of CT were being developed interactively over time in science classes of an Elementary School class.

Theoretical Foundation: Critical Thinking in Science Teaching

Authors frequently cited in theoretical definitions of CT in the field of Science Education are: Robert H. Ennis, Diane F. Halpern, Rui M. Vieira and Celina Tenreiro-Vieira, and Deanna Kuhn. Their central ideas provide us with an overview of how research in the area has operationalized the concept of CT. In general, these authors understand that critical thinking is related to considering evidence for decision-making and positioning and a willingness to do so (Cruz & Güllich, 2024).

In this work we have chosen to use the definition of critical thinking proposed in the work of the Spanish research group RODA (Reasoning, Discourse and Argumentation). Jiménez-Aleixandre and Puig (2022) define CT as a set of skills and willingness that enable critical decision-making, based on reasons, values and independent reasoning. The authors propose a holistic characterization of CT, taking into account not only dimensions related to argumentation, which most definitions of CT take into account, but also dimensions that include critical action and identities.

A significant part of the theoretical contribution of these authors is based on the proposals of Kuhn (2019). Seeking to improve the concept of CT, this author states that, "more than an individual skill or ability, critical thinking is initially engaged in an interactive way and then through practice in an internalized way" (Kuhn, 2019, p. 149). This means that CT cannot be learned by students through instruction alone, but must take place in practice. In the classroom, this is achieved through the promotion of discursive activities on complex issues that, over time, legitimize norms about what constitutes acceptable contributions to discourse. These real discussions lead to the internalization of living, though ultimately internalized, dialogical structures. Kuhn (2019) states that the intellectual discourse practiced in educational environments "include not only enhancement of the quality and productivity of this discourse itself, but the thinking engaged in by individuals" (p. 150). It is in this process that students become committed to the practice of CT.

This assumption entails methodological research implications. If we consider CT to be a dynamic activity, developed through engagement in practice, and as students have the opportunity to participate in discursive processes, their way of engaging in discussions becomes more complex, this implies that our research should seek to understand such processes over time through the analysis of discursive interactions. It is within this framework that we situate our work.

Still on the authors' characterization of CT, Jiménez-Aleixandre and Puig (2022) sought to include *critical action* in the description. The concept of CT that encompasses social change is based on the discussions developed by Davies and Barnett (2015). The authors propose the concept of *"criticality"*, a vision that includes not just skills and willingness, but a vision that includes action. In this regard, Brocos and Jiménez-Aleixandre (2022) state:

> *Criticality* comprises critical thinking, critical reflection and critical action, thus combining the traditional view of CT as the evaluation of evidence and the disposition to consider a range of views, with perspectives from critical pedagogy and critical theory, emphasizing critical citizenship. This new approach would mean both engaging in critique of discourses concealing particular interests and power games, and participating in action concerned with environmental and social justice (Brocos & Jiménez-Aleixandre, 2022, p. 217).

Jiménez-Aleixandre and Puig (2022), based on discussions by Danvers (2016), also consider the inclusion of identities in the construct. The authors state that it is necessary to take into account who the people are who engage in discussions and make decisions. Identities are lenses that shape how they personally engage with an issue. This means that CT should promote lenses that problematize inequalities and promote social change.

Based on these assumptions, Jiménez-Aleixandre and Puig (2022) proposed a characterization of CT that includes four components or dimensions: *cognitive and epistemic skills, critical character, ability to develop independent opinions,* and *critical action*. The first two components can be grouped together as they relate to commitments to epistemic criteria and evidence. The other two relate to commitments to independent thinking and civic action.

The first component of CT, **cognitive and epistemic skills**, relates to the development and use of epistemic standards or criteria in the construction and evaluation of knowledge. This component refers to the negotiation of responses to disagreements about ways of constructing knowledge (Jiménez-Aleixandre & Puig, 2022). In the classroom, some examples of practices that indicate the development of this component are: reaching a conclusion from initial hypotheses based on available data or information; presenting reasoning in the form of a convincing argument; identifying and evaluating the knowledge and results obtained (Puig et al., 2023).

The second component, **critical character**, "involves open-mindedness and a willingness to consider evidence which would contradict previous beliefs and threaten established worldviews" (Brocos & Jiménez-Aleixandre, p. 218, 2022). Related to this component is the process of forming a scientific identity. Its role in CT is decisive because the way people evaluate information is shaped by their identities (Jiménez-Aleixandre & Puig, 2022). In the classroom, examples of practices that indicate the development of this component are: considering favourable or contradictory evidence in relation to the position taken and reviewing points of view (Jiménez-Aleixandre & Puig, 2022).

The third component is the ability to develop **independent opinions** and challenge socially and culturally established ideas. In other words, it is the ability to analyse one's own opinion and majority ideas and related background assumptions. McIntyre (2018) highlights the complexity of this component by stating that "we can disregard even the evidence of our own senses if we think that our beliefs are not in harmony with those of the people around us" (p. 39). In the classroom, some examples of practices that indicate the development of this component are: seeking solutions that seek the good of the community; assessing the risks and consequences of the problem for the community; presenting characteristics of a more democratic, dialogical and humanizing posture (Silva et al., 2024).

The fourth component, **critical action**, is divided into two components: *critical awareness* — the ability to analyse and criticise inequalities and the discourses that justify them — and *critical participation* — which is related to action, resisting asymmetrical and power relations (Jiménez-Aleixandre & Puig, 2022). This component is related to "the need to modify social or individual behaviours and the identification of obstacles that preventing change" (Brocos & Jimenez-Aleixandre, 2022, p. 213). In the classroom, some examples of practices that indicate the development of this component are: carrying out a reading of reality by understanding the root of the problem; expressing interest in solving a problem with social justice, equity and sustainability; presenting mental flexibility and willingness to dialogue; presenting a proactive stance with a view to reacting to change (Silva et al., 2024).

Objective and Research Questions

Considering the specificities of each of the components of CT and the challenges of developing them in the classroom, we present an analysis of interactional data in science classes. These data were collected in a class throughout the 8th and 9th years of Elementary School. We mapped different activities that favoured the development of CT over these two years and selected a lesson in which these components were more visible in the discursive interactions of the class. Thus, we aimed to provide illustrative examples of CT in *development context* (Kuhn, 2019). In other words, we do not consider that the interactions portray students as critical thinkers in their "final form", but rather in the process of construction. We sought to understand how and which resources constructed in the past were evoked for critical participation and, consequently, became resources for future events.

Specifically, we transcribed interactions in a debate about genetically modified foods, which took place at the end of the 9th grade, in which components of CT were identified. In this debate, students positioned themselves as opposed, favourable or undecided regarding the release of the production and consumption of genetically modified products. Based on the analysis of these interactions, we evaluated how the students positioned themselves critically in the debate. We then extended our analysis by seeking to understand how the resources evoked by the students to position themselves critically in the activity were developed over time.

Specifically, we sought to answer the following questions: (1) How CT components were developing in the interactions of a class debate? Next, we established relationships with past events in which different activities fostered the development of CT, seeking to answer: (2) How have different elements of the instructional context experienced by the class in 8th and 9th grade become resources for the development of CT components?

The components of CT were identified based on the four components proposed by Jiménez-Aleixandre and Puig (2022). More precisely, we asked ourselves with regard to the first component — *cognitive and epistemic skills* — whether the students based their position on evidence and developed arguments in order to participate adequately in the debate. We sought to understand the epistemic criteria used by the students to position themselves. That is, whether they sought to take informed positions and were willing to put these arguments under analysis.

With regard to the second component — *critical character* — we paid attention to whether the students were open to considering evidence or arguments contrary to the position taken in the debate. In other words, whether, when seeking evidence on the topic, they collected and used evidence that did not support the position they had taken, and whether they were willing to consider other arguments and were tolerant of evaluation.

With regard to the third component — *independent opinions* — we examined how students challenged their own ideas or majority positions. In other words, we analysed whether they, when putting their arguments under analysis, were able to consider peer evaluation in order to make decisions that sought the collective good, rather than the protection of their own beliefs or dominant positions.

With regard to the fourth component — *critical action* — we examined the existence of spontaneous references to the need to change social or individual behaviour and the identification of obstacles to these changes.

Research Methodology

Research Context

The research was conducted at a school located on the campus of a federal university in south-eastern Brazil. Data construction occurred when students were in the 8th and 9th grade of Elementary School, 2019 and 2020/2021, respectively. The debate analysed took place when the class was in the 9th year of Elementary School. This year the group was made up of 25 students, 11 boys and 14 girls. It is worth noting that in the 9th grade, classes took place remotely between 2020 and 2021 due to the Covid-19 pandemic.

The students were socio-economically diverse because they entered the school by lottery. The science teacher of the class in the two years of collection was Sandro.[1] He had 20 years of teaching experience and a solid academic background: a degree in Natural Sciences, a master's degree in Science and Mathematics Teaching, and a doctorate in Education with an emphasis on Science teaching. In his teaching practice, Sandro encouraged class participation by proposing questions and stimulating discussions among the students. It was common for the teacher, even in a lecture class, to raise questions or encourage interactions between peers. He also developed sequences guided by Inquiry-Based Science Teaching (IBST) (Pedaste et al., 2015) and the use of socioscientific issues (SSI) (Nunes-Neto & Conrado, 2021; Zeidler et al., 2009).

Figure 1 summarizes the topics studied by the class over the last two years of Elementary School and the inquiry-based activities and socio-scientific debates developed.

Figure 1

Instructional context of the class throughout the 8th and 9th grades of Elementary School

Year	Semester	Content	Main Activities
2019	1st	Cytology; Urogenital System; Nervous System; Sense Organs.	Socio-scientific debate on stem cells; Inquiry-based sequence on phantom limb pain; Inquiry-based sequence on the relationship between smell and taste.
	2nd	Cardiovascular System; Immune System; Respiratory System.	Inquiry-based sequence on the difference in thickness of the atria and ventricles; Inquiry-based sequence on the change in colour of bromothymol blue and variation in respiration rate; Socio-scientific debate on electronic cigarettes.
2020	1st *(classes suspended in March)*	Food Composition; Anatomy and Physiology of the Human Digestive System.	Inquiry-based sequence on salivary amylase. Discussion on Covid-19 (before social isolation).
	2nd *(remote classes from August to December)*	Anatomy and Physiology of the Human Digestive System; Genetics; Evolution.	Inquiry-based sequence on Mendel's laws (Face to face with Genetics); Discussion of vaccines; Socio-scientific debate on genetically modified foods.
2021	1 *(remote classes in January and February)*	Evolution	Inquiry-based sequence on biodiversity (Unravel me or I will devour you); Inquiry-based sequence on biodiversity and evolution (using *PhET* software).

1 We used pseudonyms to identify teachers and students, aiming to protect the identities of the subjects involved in the research. We guide data collection and analysis based on ethical principles of research with human beings (Spradley, 1980). We had authorization from the School Board and the Ethics Committee of the responsible institution to carry out the research. We also talked to the students about the research, its objectives and how the data would be used. The adults involved — *parents, teacher and trainees* — signed a Consent Form. The project was assessed and approved by the Ethics Committee of the institution carrying out the research with the CAAE registration: 40153420.8.0000.5149.

Research Logic

In this study, we used assumptions and tools from the ethnographic perspective in Education as a research logic (Bloome et al., 2005; Green et al., 2005). Based on indications from Green et al. (2005), we sought to understand the monitored classroom as a culture. Culture, in this context, does not refer to a fixed map of beliefs or values, but to the daily construction of events through interactions in a social group. An event, in this conception, refers to "bounded series of actions and reactions that people make in response to each other at the level of face to-face interaction" (Bloome et al., 2005, p. 6). People act and react to each other through discourse, and discourse can be understood as language in use, both verbal and non-verbal (Bloome et al., 2005).

One of the ways in which the ethnographer makes visible distinct aspects and practices of a culture is by identifying rich points (Agar, 1994). Rich points are moments in which there is a frame clash, that is, a break in the expectation of the ordinary course of a group's actions. Events in which breaks in expectations are identified serve as anchor points for analysis. However, the logic of ethnographic research is not based on the interpretation of isolated events, but understands that everyday situations are embedded in broader contexts that are mutually constitutive.

We believe that these assumptions converge with the dialogical vision of CT. Therefore, we analysed an event through the analysis of the actions and reactions of the participants, mapping CT components based on indications present in the participants' discourse. We then expanded our analysis by contrasting the events of the main event with other events over time, observing approximations and distances, continuities and changes capable of highlighting important aspects of the development of CT components by the class over time.

Data Construction and Analytical Processes

To construct our data, we used ethnographic research tools, namely: participant observation (Spradley, 1980), field notebook recording, audio and video recordings, photographs, as well as the collection of artifacts produced by the students (Green et al., 2005). Using the data gathered during the observations, we created an Excel® spreadsheet called the "Lesson Chart". This table gathers general information about the lesson and allows us to construct a holistic view of the class's daily life.

Among the sequences developed, a debate that took place at the end of 2020, when the class was learning Genetics content, caught our attention. Interactions from this debate were selected for analysis in view of their analytical potential. A debate around a socioscientific issues (SSI) favours the exposure of ideas and arguments of different natures, which gives greater visibility to the CT components under development (Kuhn, 2019). In previous activities, the class had already discussed other socioscientific issues (SSI) in the form of debates (legalization of electronic cigarettes, planting eucalyptus trees and stem cells). However, this was the first time that the teacher did not provide data or data sources to prepare for the debate. The teacher simply introduced the topic,

asking the students to think about it and prepare themselves based on their own research. This aspect of this lesson caught our attention as it helps us understand what norms and practices students have appropriated related to CT components over time and used them as resources for participation considered appropriate in the context of a debate.

To answer our first research question, we transcribed the interactions that occurred by identifying *message units*[2]. We then identified the components of critical thinking in the participants' speeches. To answer our second research question, we sought to weave connections between the main event and other events in the class's history. To do this, we went back and forth in the history of the class to identify and understand norms and practices that became resources for the development of the critical thinking components observed in the main event.

In analysing the broad history of the group, we selected lessons in which students engaged in discussions related to scientific and socioscientific issues. We analysed the instructional context and discursive interactions of each of these events, seeking to identify how the group engaged in practices related to the elaboration, evaluation of arguments and evidence, and other related practices. The aim was to understand how, by participating dialogically in the practice, the students developed resources that were mobilized in the main event, in the future.

Results and Analysis

On the day of the debate, based on the research carried out previously, the students positioned themselves in the discussion as favourable, unfavourable and undecided. The teacher explained that the class would play the role of a political authority in order to assess the release of the production and consumption of genetically modified products in our country. The teacher then separated the favourable and unfavourable groups into separate virtual rooms so that they could prepare for the discussion, articulating their research and organizing their arguments. The undecided group, in turn, had to think of questions to ask the other two groups. After these preliminary discussions, all the groups were brought together in the same virtual room to hold the debate.

We present our results from three events[3]: the first related to the discussions of the favourable group, the second related to the discussions of the opposing group, and the third related to the debate with the whole class. We did not present the discussion of the undecided group, as many of the points discussed by the group appeared during the collective debate. Therefore, due to the length of the work, we have chosen not to present these interactions.

2 Message units are the smallest unit of analysis in an event. They are not limited by grammatical rules, but by contextual clues. Contextual clues are any features of linguistic form that contribute to signalling contextual presuppositions (Gumperz, 1982). Contextual clues used in the analysis of discursive interactions: ↑ (increased intonation at the end of speech); XXXX (indecipherable speech); emphasis; ▲ (higher volume); ▼ (lower volume); statement with lower speed; statement with higher speed; ┐ └ (overlapping speeches); vowel+ (elongated vowel); *Chat conversations in italics;* | (pause); ||| (long pause); - (incomplete word); *asterisk* (voice, tone or style changed); "quotation marks" (Reading a written text).

3 Given the limitations of the layout, we have selected excerpts from the three events for analysis. The full transcript of each event can be accessed at: Franco, L. G., (2025). Transcription of Discursive Interactions – Project CAAE: 40153420.8.0000.5149. https://doi.org/10.7910/DVN/K6XP1R, Harvard Dataverse.

The Preparation of the Group in Favour of the Use of Genetically Modified Products

The discussion of the favourable group (Figure 2) began with a survey and analysis of possible arguments that the unfavourable group could use.

Figure 2

Interactions from Event 1 (favourable group)

Line	Speaker	Message Unit	CT components
1	Teacher in training Daniela	Hi guys|	
2		Do you want to share why you think you're favourable↑	
3	Bárbara	There's a study that+	CES
4		When I was looking for studies that proved diseases|	
5		Caused by genetically modified food|	
6		There's one that I thought was+	
7		That they can use against us|	
8		If they've researched that it's because+	
9		There's a university in France|	
10		They did tests on rats|	
11		They divided 200 rats and+	
12		One group ate the genetically modified food|	
13		Then they died earlier than expected|	
14		And suffered from cancer|	
15		But it's like|	
16		It *could* happen to us|	
17		It could|	
18		But I didn't think it was done with humans and they died|	
19		Because it can't right|	
20		But+	
21		If they use this against us it'll be a good argument for them|	

Figure 2

Interactions from Event 1 (favourable group) (continuation)

Line	Speaker	Message Unit	CT components
22	Perseu	No it won't|	CES
23		Because+	
24		It's like|	
25		We've been using it for a long time|	
26		And+ to date there has been no case|	
27		That genetically modified food caused something|	
28		It may have happened to a rat|	
29		But with us there's nothing proven|	
30	Bárbara	That's why I thought|	CES
31		But+	
32		If there are studies that they have died of cancer|	
33		Maybe one day we'll die too|	
34		But *one day*	
35	Perseu	They haven't proven anything yet	

Bárbara began the discussion with her colleagues by proposing the construction of counter-arguments (L3–21). The student began her speech by emphasizing: "There is a study that+" (L3), indicating that for her the resolution of the question would be through the analysis of evidence. Thus, we identified the "*cognitive and epistemic skills*" component, as the student highlighted the importance of evidence and sought to construct counter-arguments. However, despite taking into account opposing evidence, we have no evidence of the critical character component, as the students were more committed to identifying the weak points of the evidence in order to refute it at the time of the debate, and not necessarily in the search for a fair decision (L6–7). Perseu evaluated the evidence, contrasting it with the evidence that there were no studies linking the consumption of these foods and diseases in human beings (L22–29). However, Bárbara evaluated her argument and proposed that perhaps the same harm could affect human beings (L30–34), thus considering the scope of the evidence. Therefore, we consider that the two students were engaging in practices from the "*cognitive and epistemic skills*" component, as they were evaluating evidence in discussion.

The Preparation of the Group Opposed to the Use of Genetically Modified Products

In the preparatory discussion for the unfavourable group, we also observed the mobilization of CT components.

Figure 3

Interactions from Event 2 (Excerpt 1)

Line	Speaker	Message Unit	CT components
64	Teacher in training Natália	Benício is also talking here in the chat|	
65		"I'm unfavourable because the production of genetically modified food brings more benefits to the producers than to those who consume it"	IO
66		Do you want to talk a bit about that↑	
67		Benício↑	
68	Benício	Oh teacher|	IO
69		That's what I wrote in the chat|	
70		Of course there are some benefits for those who consume|	
71		But they are more for those who produce and+|	
72		The harm ends up being-|	
73		The negative points end up being mor+e|	
74		Relevant than the positive points|	
75	Trainee Natália	And what do you think are the benefits for producers↑|	
76	Benício	Wait a minute I'll take it from where I wrote it|	IO
77		It's+|	
78		Where is it↑▼|	
79		"Increased and improved productivity"|	
80		"Reduction of production costs"|	
81		I think the expansion of scientific knowledge also counts|	
82		It's+	
83		"Greater resistance to pesticides"|	
84		"Insecticides"|	
85		"Herbicides"|	
86		"And pests like insects viruses bacteria and fungi"|	
87	Teacher in training Natália	I thought it was cool┐	
88	Benício	└Then there are the disadvantages|	
89		Can I read↑|	
90	Teacher in training Natália	Ye+s|	

Figure 3

Interactions from Event 2 (Excerpt 1) (continuation)

Line	Speaker	Message Unit	CT components
91	Benício	See	IO
92		"Possibility of developing health problems"|	
93		"Such as allergic reactions"|	
94		"Can cause diseases such as cancer or be poisonous to humans"|	
95		"Loss of biodiversity"|	
96		"Disappearance of species and contamination of seeds"|	
97		"Encouraging the emergence of more resistant pests"|	
98		It's+ |	
99		"Occurrence of soil, water and air pollution" |	
100		"It harms small farmers because genetically modified species are protected by patents"|	
101		And+	
102		"Increases human resistance to antibiotics"|	
103		Imagine that with the coronavirus|	
104		Like |	
105		You are+|	
106		Genetically modified food increases your resistance to the virus|	
107		For example	
108	Teacher in training Natália	Got it |	
109		So you weighed up the positives against the negatives|	
110		You thought the negative points weighed more heavily, right↑|	

Benício began by clarifying that there was conflicting evidence and sought to analyse it critically (L65; 68–74; 76–86). In this case, we consider that the "*independent opinions*" component of critical thinking was being developed. For Benício, the evidence found regarding the legalization of genetically modified food production was in favour of producers. The analysis of the student had complex epistemological foundations. Not only did he recognise that it was through evidence that the class would reach a consensus (L76 and 89), but he evaluated it in relation to the underlying preferences it might carry. For him, this evidence supported large producers (L65 and 100). In this way, we consider that the student sought the collective good, as well as challenging majority capitalist ideas. Furthermore, when the student presented evidence related to disadvantages (L91–107), he brought data that were related to health (L92–94 and 102), the environment (L95–99) and the small producer (L100), that is, he took into consideration evidence that supported marginalized options.

In the continuation of the previous discussion of the group opposed to the legalization of the production and consumption of genetically modified food, after Benício brought his contributions, teacher in training Natália reminded the students that someone should be responsible for sharing the discussions made in the small group with the whole class (Figure 4).

Figure 4

Interactions from Event 2 (Excerpt 2)

Line	Speaker	Message Unit	CT components
164	Teacher in training Natália	Someone volunteers to+	
165		To start the debate in the large group↑	
166		Would anyone like to speak↑|||	
167	Karla	Look I don't want to|	CES
168		Because |	
169		Until recently I didn't know what this subject was |	
170		I found out in this class |	
171		And until now I was Googling to see what it was|	
172		And seeing if I'd chosen the right group to join|	
173		Teacher Sandro actually put me in the wrong group |	
174		I was supposed to be in the favourable one|	
175		Because I had put favourable in the chat |	CC
176		But then I went there and said |	
177		*You know*|	
178		*The unfavourable also seems to be nice*|	
179	Teacher in training Natália	It's nice that you're open to other opinions|	
180		That's also important in building our-|	
181		Our own opinion right|	
182		On any subject|	
183		And what do you think↑|	
184		Within your research	
185		Have you changed your min+d	
186		Do you still think you're+|	
187		You're more favourable↑|	
188		Or have you already changed your mind↑|	

Figure 4

Interactions from Event 2 (Excerpt 2) (continuation)

Line	Speaker	Message Unit	CT components
189	Karla	No	CC
190		Seeing here |	
191		And seeing like|	
192		What you've said and so on |	
193		I think+|	
194		It's better to be unfavourable|	
195		For the various reasons you've mentioned|||	
196	Teacher in training Natália	Nice|	

In this interaction, when it was proposed that someone should be responsible for sharing the discussions held in the small group with the class, Karla told her colleagues that she was unaware of the dynamics that would occur in the class and therefore she had not prepared. However, when she found out about the activity underway, she quickly began to do her research (L167–171). This move by the student indicates her commitment to the participation considered appropriate by the class: the position should be based on evidence, revealing that the "*cognitive and epistemic skills*" component was being developed.

Karla shared with her colleagues that she was also in the wrong group. She had initially told teacher Sandro that her position was favourable. It was interesting how the student had, without the use of evidence, taken a position in the debate. However, when she started reading about the subject, she changed her position (L175–178; 189–195). This aspect shows the development of the "*critical character*" component of critical thinking, as the student was open to considering evidence contrary to her initial position.

The movement of the student was encouraged by the teacher in training (L179–188). Natália emphasized that this movement would not be restricted to the discussion of that lesson, but to any subject. This emphasizes to the students that this way of conceiving opinions and taking positions extended to contexts outside the classroom.

Divergent Visions Meet

After the discussion in the small groups, the favourable and unfavourable students met with the group of undecided students in the virtual classroom for a collective debate

(Figure 5).

Figure 5

Interactions from Event 3 (Excerpt 1)

Line	Speaker	Message Unit	CT components
228	Lara	It's because+	IO
229		The population will only increase|	
230		And for that you'll need more places to deforest to be able to grow food|	
231		Having something that would be easy to grow and wouldn't spoil so easily|	
232		It would help a lot not to deforest more areas and to be able to use the same area we have today|	
233		To produce more food by+	
234		Like 2050|	
235		To increase the population	
236	Perseu	Well|	IO
237		It's not just that either|	
238		There's also the issue that genetically modified food is much cheaper than natural food|	
239		So for the poor population|	
240		Buying natural food is much more difficult because the loss in production is huge right↑	
241		Because there are so many pests|	
242		And then it is much cheaper for the poor population to also be able to buy and so on	
243	Lara	That's true|	CES
244		But as long as there are no more in-depth studies on the diseases they may cause|	
245		I still have my doubts|	
246		Because what's the point of something being cheaper if it can kill you↑	
247	Perseu	I'm favourable|	CC
248		But there's also the question of study|	
249		I think we still have to get to know the thing properly because+	
250		I don't know|	
251		We don't know much|	

...

Figure 5

Interactions from Event 3 (Excerpt 1) (continuation)

Line	Speaker	Message Unit	CT components
294	Perseu	Here's|	CES
295		Just one question|	
296		I remember that Lara said|	
297		That over time effects could start to appear and I took a look|	
298		We've been using genetically modified foods for almost 30 years and to date we haven't had any cases of any health risk|	
299		And another thing I remember Benício saying|	IO
300		Which was about the use of pesticides that+	
301		You spend less right↑	
302		Because you need fewer pesticides|	
303		I remember Benício saying that|	
304		The high use of pesticides|	
305		As well as affecting the soil and internal rivers|	
306		Can affec+t	
307		Let's say|	
308		It goes into a lake|	
309		That lake could affect some animal that lives there or some pla+nt	
310		Some primary sector and it may worsen in others|	
311		Tertiary sector|	
312		The food web of that place|	
313		So it's not just a country thing|	
314		Understand↑	
315		It's something that involves all of nature around it|	
316		The use of pesticides	
317	Nara	About what you said|	CES
318		I think it's actually very risky for you to say that because+	
319		The studies on genetically modified food are very current|	
320		So you can't say for sure that they don't cause anything|	
321		Like|	
322		I only saw one source about this that they don't cause anything|	
323		But|	
324		This source is kind of old and also everywhere you look it will be saying that there is a risk in genetically modified foods|	
325		And since we don't have enough studies since the study on them is something very recent|	
...			

Figure 5

Interactions from Event 3 (Excerpt 1) (continuation)

Line	Speaker	Message Unit	CT components
342	Perseu	I agree with you|	CES
343		But I didn't say it doesn't cause it|	
344		I said that we've been using them for almost 30 years and we haven't had any symptoms	
345		And I found a video|	
346		From the doctor right|	
347		Drauzio Varella|	
348		Everyone knows him|	
349		And he says that in science there's no risk|	
350		Nobody comments on that|	
351		I can send you the video so you can see|	
352		His link|	
353		It's towards the end|	
354		It's there towards the middle slash end|	
355		If you want I'll send it to you |	
356	Nina Costa	Can I tell you something|	CES
357		So like this|	
358		You mean we can trust this source|	
359	Perseu	It's a good source|	
360		I'm not saying I'm 100% sure	
361	Nina Costa	Calm down|	CES
362		Calm down|	
363		We can trust this source|	
364		And in *some way*	
365		Devalue dozens of other sources we have|	
366		To trust just two|	
367		Which are the two I've seen so far|	
368		In this case the one you just sent me|	
369		And like one that wa+s|	
370		Another one you mentioned|	
371		But like|	
372		It's+ |	
373		All the other sources I looked at|	
374		Were contradicting this one|	
375		So we're going to dispense with dozens to rely on two↑	

Figure 5

Interactions from Event 3 (Excerpt 1) (continuation)

Line	Speaker	Message Unit	CT components
376	Lara	Just adding to what Nina said|	CES
377		Perseu|	
378		This stuff of 30 years of study is a very recent thing|	
379		Have you ever thought that this is a small amount of genetically modified foods|	
380		Because it wasn't totally controlled|	
381		So|	
382		I don't know|	
383		There's maize|	
384		There's soya|	
385		There are other foods but they're very little produced|	
386		As soon as this is released and all foods are genetically modified|	
387		What will the risk rate be like↑	
388		Will it continue to be none↑	

Student Lara began her speech by sharing with her colleagues the advantages of legalizing the production and consumption of genetically modified food. The student positioned herself as unfavourable in the debate, but nevertheless raised a favourable argument. In her opinion, with the increase in the world's population, it would be necessary to produce more food and, consequently, there would be greater deforestation. An advantage in this scenario would be the production of genetically modified food (L228-235). Therefore, the student was not only open to considering evidence contrary to the position taken, but also considered evidence that supported marginalized options. Thus, we consider that the student engaged in practices related to the "*independent opinion*" component of CT.

Perseu (favourable) complemented his colleague's speech and said that genetically modified foods are cheaper and therefore more vulnerable populations could have access to them (L236–242). He was therefore appropriating practices from the "*independent opinion*" component. His speech sought the collective good, especially for the economically disadvantaged. However, as the debate continued, Lara reminded her colleagues that, although there were advantages, it was necessary to consider the evidence that there were not enough studies to prove the non-existence of diseases caused by the consumption of genetically modified foods, so it would not be an advantage for vulnerable populations if the food they were able to access caused diseases (L243–246). We believe that the student's reaction is related to the "*cognitive and epistemic skills*" component. The student evaluated her colleagues' argument about the access of economically disadvantaged people to low-cost food by relating it to another piece of

evidence: the development of diseases. Regarding his colleague's speech, Perseu, who was favourable, agreed with his colleague's proposition, showing himself open to considering the argument contrary to the position taken (L247–251). Therefore, we consider that practices of the "*critical character*" component were being mobilized.

However, in the sequence, it seems to us that Perseu went back and evaluated Lara's proposition. It seems that the student did a quick search ("I took a look|" L297) and went back on his position that there was not enough evidence to prove the non-existence of a relationship between genetically modified foods and disease. The student evaluated his colleague's argument and proposed: "We've been using genetically modified foods for almost 30 years and to date we haven't had any cases of any health risk|" (L298). Therefore, we believe that the student was appropriating practices from the "*cognitive and epistemic skills*" component.

In addition to this, Perseu said that his colleagues should not forget that a lot of pesticides are used on non-genetically modified food, which is not only bad for the consumer, but pollutes rivers that can affect animals and the inhabitants of these areas. By bringing in another piece of evidence that corroborated his position, and this piece of evidence, in turn, was related to the environment, we consider that the student was appropriating practices from the "*independent opinion*" component of the CT. In the Western capitalist context, taking into account evidence that points to environmental issues that are usually in the background can be considered a challenge to majority positions.

Next, Nara (unfavourable), evaluated Perseu's evidence (L317–325). The student shared with her colleagues that studies on genetically modified food can be considered current. That is, 30 years may not be enough for diseases to be linked to the use of these foods. The student said that in her research she observed that there was only one source that stated that genetically modified food did not cause diseases and this evidence was old. Therefore, when analysed in the light of the consensus in the field on the subject, this source lost its credibility. In this way, we believe that the student considered the epistemic criteria of expert consensus and the timeliness of the source, appropriating practices from the "*cognitive and epistemic skills*" component of the CT.

Corroborating her colleague's argument, Lara (L376–388) stated that in addition to these studies being old, a new variable has emerged with the advancement of technology, that is, more varieties of genetically modified foods are being produced and consumed. So perhaps diseases did not arise when few genetically modified foods were consumed, but now, almost no food comes from its natural source. Therefore, the epistemic criterion validity of the evidence was raised by the student. Therefore, we believe that the student was appropriating practices from the "*cognitive and epistemic skills*" component of the CT.

Perseu evaluated his colleague's evidence by bringing in another piece of evidence. The student stated that, in fact, there is a scientific consensus that there are no risks associated with consuming genetically modified foods. The student sought to give credibility to his evidence by appealing to his source: a renowned Brazilian doctor, Dr. Drauzio Varella (L342–355).

Therefore, we consider that the student was appropriating practices from the "*cognitive and epistemic skills*" component, as he evaluated the merits of his colleague's evidence, bringing in other evidence. However, Nina (neutral) also mobilized practices from the "*cognitive and epistemic skills*" component (L356–358; 361–375). The student evaluated the source proposed by Perseu. For her, no other study confirmed this, therefore, the possibility of developing diseases could not be disregarded based on the speech of just one scientist.

Thus, in this interaction we were able to observe different epistemic skills being required and used by the students, such as evaluating arguments considering various pieces of evidence and evaluating evidence considering consensus and validity. The participants' actions and reactions reveal the ways considered appropriate for the construction of knowledge for that class.

In the continuation of the debate, Bárbara (favourable) spoke up (Figure 6).

Figure 6

Interactions from Event 3 (Excerpt 2)

Line	Speaker	Message Unit	CT components
612	Bárbara	Yes|	
613		I believe that+|	CA
614		Having basic information on food should be mandatory|	
615		I'm in favour of that|	
616		And of putting the necessary information|	
617		But+	
618		As I-	
619		As you said right|	
620		There's no way of knowing if the cancer came from|	CES
621		Necessarily from the genetically modified food|	
622		Or it came from other factors|	
623		If it did I think there would be more evidence|	
624		Because |	
625		Throughout my research|	
626		That I did|	
627		I didn't see any evidence that it was necessarily the fault of genetically modified food|	
628		It could be from+|	
629		It's+|	
630		Environmental space|	
631		It could be from several things|	
632		So then|	
633		I don't know▼|	

In the continuation of the debate, Bárbara (favourable) proposed that, given the controversy, a solution would be for the product packaging to identify the origin of the product (L613–616). Bárbara's speech refers to how the issue could be considered in her daily life. For her, there should at least be signs for the consumer who, based on her analysis, would decide whether or not to consume the product. As such, we believe that her position reflects the "*critical action*" component, as it shows an analysis aimed at decision-making, in which the power of control over what is consumed is sometimes not very accessible.

Following on from this, Bárbara also stated that genetically modified foods have been consumed for a long time and there is no study to prove their relationship with cancer (L620–633). Therefore, we believe that the student evaluated her colleagues' arguments about the lack of evidence proving the non-existence of the relationship between genetically modified foods and diseases, relating them to other studies. Therefore, we believe that the student was appropriating practices from the "*cognitive and epistemic skills*" component of the CT. However, if we compare the student's speech with the discussion with her group before the moment of debate between the parties, Bárbara had mentioned a study with rats that indicated death from cancer. Nevertheless, at the time of the debate, the student said that she had found no evidence that genetically modified food caused cancer. Perhaps the student was still aiming to win the debate, since at the time of the discussion with her group, she tried to evaluate the evidence in order to be prepared for the debate. The student's position deviates from the criticality proposed by Brocos and Jiménez-Aleixandre (2022). We believe that she tried to evaluate the evidence in order to find weak points and, as she was not sure about this refutation (L30–34), she was not open to presenting the evidence for the discussion.

Coming to the end of the debate, Nina Costa (neutral) asked the favourable group to give a solution to population growth and the possible lack of food. Lara took a stand on this (Figure 7).

Figure 7

Interactions from Event 3 (Excerpt 3)

Line	Speaker	Message Unit	CT components
683	Lara	You know|	CA
684		To be honest|	
685		Genetically modified foods would be a great solution for this|	
686		But|	
687		I think there should be a much more in-depth study about it|	
688		Even though there are several|	
689		In order to really know the causes|	
690		Because so far these studies have been based on a low intake of genetically modified food|	
691		Because not all foods are like that|	
692		Besides the fact that it's only been a few years up to date|	
693		So if it's something more in-depth|	
694		And having a major impact over the years|	
695		And transgenics are proven to be good|	
696		That would be a great solution for the population to have food in a few years with its increase|	
697		But|	
698		If that's not possible|	
699		The way is to deforest everything and plant	

The group had already discussed the issue of population growth and the lack of food. They had already discussed that, as a result of population growth and improvements in food production through genetically modified technology, less of the environment could be deforested and fewer pesticides would need to be used. In addition, the low-income population could have access to these foods due to lower production costs and, consequently, lower prices on the market. However, Nina Costa wanted to know what solution the favourable group would propose to the impasse between the possible deaths caused by the consumption of genetically modified food and the deaths caused by the lack of food due to population growth. Lara pondered the various arguments in favour (684–685), but also pointed out the contrary evidence discussed throughout the debate. There was a need for more recent studies (L692), longitudinal studies (L694) and studies that took into account the increased diversity of intake of genetically modified products (L690). Therefore, given the controversy, it was better for deforestation to occur than for people to die from the long-term use of a product that had no scientific proof of its consequences. Even considering the "*critical action*" component in the student's speech, by proposing a solution that she considered a lesser evil, aspects of the four components

were intertwined in her proposal. This is because the solution was based on evidence and collective reasonableness, even though it was contrary, the student was open to considering different evidence and arguments, and sought to make a responsible decision considering the collective good.

A Summary of the CT Components Developed During the Debate

Our results allow us to conclude that the students in favour and against sought to use and analyse opposing and favourable evidence in order to participate in the debate. When discussing with colleagues of the same position, the component that prevailed most was *cognitive and epistemic skills*, in which students proposed to construct counter-arguments, refutation and present evidence that supported the position taken (clearer markings in Figure 8). We observed an environment in which cognitive and epistemic skills were not only related to the communication of arguments, but also to their evaluation.

Another relevant aspect: in the discussion with the whole class, the students took into account evidence that supported marginalized options (the markings with a slightly stronger tone of blue). Following the debate, it was based on this evidence and collective reasonableness, that is, on the various evaluation practices, that the discussion culminated in the proposition of critical practical actions (dark blue tone in the last lines). The figure helps us to represent a spectrum, in which, based on evidence and collective evaluation, the students sought decisions that would support marginalized groups.

Figure 8

Systematization of the CT components developed in the socio-scientific debate

Groups with Opposing Positions			
Favourable Group (F)		Contrary Group (C)	
Lines	**Component of the PC**	**Lines**	**Component of the PC**
L3-21	CES (presents evidence and proposes the construction of counter-arguments)	L65; 68-74; 76-86; 91-107	IO (evaluates evidence supporting majority options: large producers and; takes into account evidence supporting marginalized options: health, environment and small producers)
L22-27	CES (evaluates evidence in the light of other evidence)	L167-171	CES (analyses different pieces of evidence)
L30-31	CES (evaluates an argument considering the scope of the evidence)	L175-178; 189-195	CC (changes position based on analysis of evidence)
The Meeting of Divergent Positions			
Lines	**Group**	**Component of the PC**	
L228-235	C	IO (takes into account evidence supporting marginalized options: less deforestation)	
L236-242	F	IO (takes into account evidence supporting marginalized options: right to food)	
L243-246	C	CES (evaluates an argument considering other evidence)	
L247-251	F	CC (open to considering contrary evidence)	
L294-298	F	CES (evaluates an argument considering other evidence)	
L299-316	F	IO (takes into account evidence supporting marginalized options: decreased use of pesticides)	
L317-325	C	CES (evaluates the merits of evidence: validity and consensus)	
L342-355	F	CES (evaluates an argument considering other evidence)	
L356-358; 361-375	N	CES (evaluates the merits of evidence: consensus)	
L376-388	C	CES (evaluates the merits of evidence: validity)	
L613-616	F	CA (proposes a solution: signage on food so that consumers can decide)	
L620-633	F	CES (evaluates an argument considering other evidence)	
L683-699	C	CA (proposes a solution: it is better to deforest in order to have food than to put consumers at risk)	

Time ↓

Extending the Results

We analysed the instructional context and discursive interactions of activities that promoted the discussion of scientific and socioscientific issues in the class throughout the 8th and 9th grades. Figure 9 systematizes the main practices and norms developed in these activities and which became a resource for the debate on genetically modified foods. A first relevant resource in this process was the use of scientific evidence to construct and evaluate statements (see Silva et al., 2024). Looking at the figure, we can see that this practice was encouraged and provided in the class through inquiry-based activities.

For example, on 03/07/2019 (8th grade), the class used evidence to evaluate hypotheses that answered the question "Why do people with amputated limbs feel pain in the place of the limb?". In this lesson, the teacher proposed that appropriate evidence would be that generated through experiments carried out by the scientific community and published in the community's own sources. In addition, the teacher made it clear that it was through this evidence that the students would construct knowledge. In this activity, the students proposed various hypotheses which were first evaluated individually and then in small groups. The evaluation consisted of deliberating on justifications constructed by the students that related the hypotheses constructed to the evidence proposed by the teacher. Finally, the statements proposed to explain the phenomenon and which were evaluated as coherent by the groups were evaluated by the whole class, and together they reached a consensus on a better explanation for the phenomenon. In this way, various cognitive and epistemic skills could be developed, such as constructing hypotheses, using evidence, evaluating arguments and constructing socially coherent explanations.

This way of constructing knowledge was legitimized on the social level of the group, which gives us a clue to understand the attitude of student Karla, for example. The student, unaware that a debate was about to take place, sought to take an informed position through evidence. Her attitude also reveals that the students were willing to use this evidence in the collective decision-making process. We noticed that Bárbara, favourable, said "throughout my research" (L625), and Benício, in the opposite group, shared his collected information with his colleagues. The students' attitudes show how the way the group considered appropriate for making critical decisions was based on the use of evidence.

Activities related to the practice of evaluating evidence and using evidence from different domains also became a relevant resource over time. This practice was proposed more emphatically in that class after a debate on electronic cigarettes that took place in the last lesson of the 8th grade and was developed in other activities throughout the 9th grade. In the electronic cigarette debate (12/12/2019), the students in favour presented various pieces of evidence to support their position.

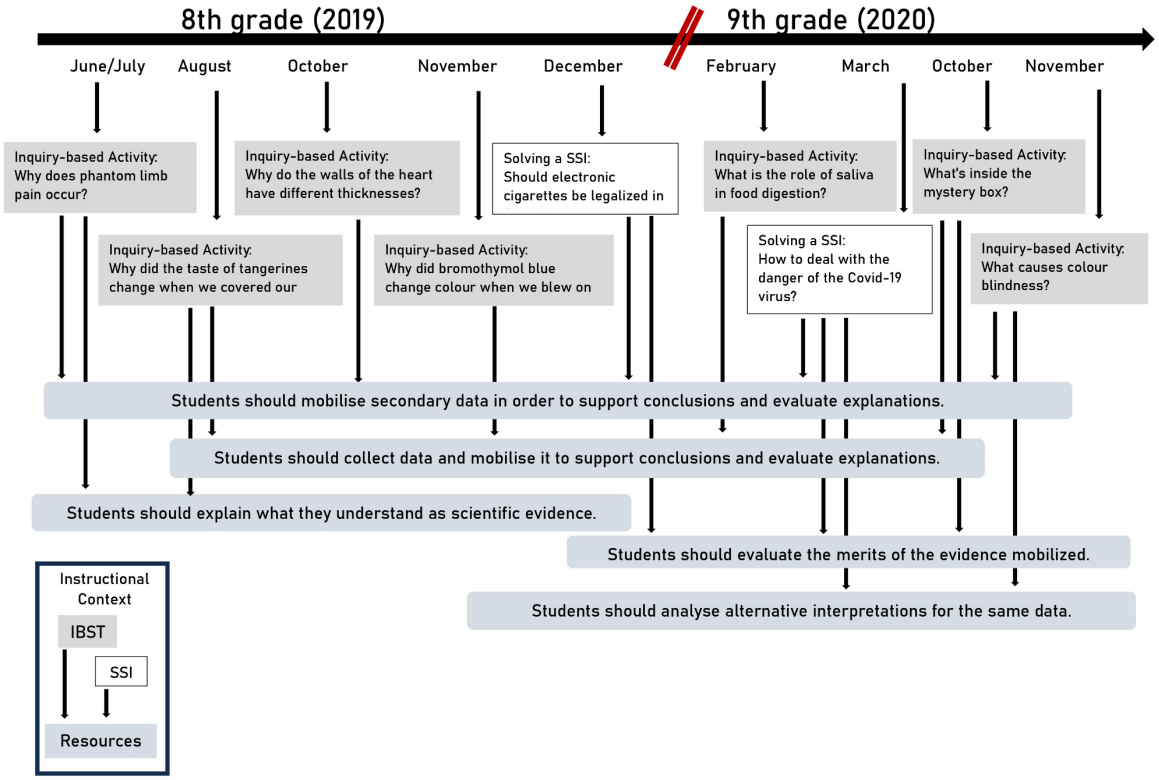
The opposing group, in turn, did not present evidence to construct arguments, which generated a wave of evaluative processes. In queue with a practice that the teacher initiated in this lesson, the favourable students responded to the class's demand by constructing alternative arguments based on the evidence brought by the opposing group, as well as mobilizing evidence from other domains of knowledge. This movement generated future repercussions, complicating the deterministic data-conclusion relationship and the sufficiency of using evidence from the scientific field to answer complex questions from society (Silva et al., 2023).

In the debate on genetically modified food, the students used and evaluated evidence from various domains (evidence from the field of Biology, Geography, Health, Economics). Benício evaluated evidence favourable to the production of genetically modified foods by pointing out his subjective preferences. Lara Tunes evaluated the argument that genetically modified foods bring benefits to consumers because they are cheaper. Nina Costa evaluated the merits of evidence defended by a few scientists. All these actions reveal that practices related to evaluating statements and evidence were being appropriated as part of the class's epistemic repertoire.

Another relevant aspect is related to the students' willingness to debate critically. For example, Benício was willing and committed to participating adequately in the discussion when he asked to read his notes on the topic. At a point in the event not reported in this article, in the discussion prior to the debate, when the group was deciding who would share the points discussed, student Lara said she would read a text she had produced for the activity. The students were willing to put their beliefs, arguments and evidence forward for evaluation, as well as evaluating their colleagues' arguments and evidence. This practice was not isolated in the group's history. If we go back to the inquiry-based activity related to the colour change of a bromothymol blue solution (21/11/2019), the teacher proposed that the groups formed to carry out the activity construct evidence from observation, develop arguments to explain the phenomenon and that each group evaluate at least the arguments developed by two other groups. This process allowed data and lines of reasoning that had not yet been considered to be subject to scrutiny. This, in turn, boosted the ongoing investigations.

Figure 9

Resources legitimized over time in the class under investigation



However, in the debate on genetically modified food, something unexpected occurred. We observed throughout the history of the class that students used evidence to support a position or argument, as was the case with the activity on the pain of the phantom limb. Then they started to evaluate evidence in order to weaken the opposing position, as was the case in the debate on electronic cigarettes. However, in the event analysed in this work, we observed that the students began to point out possible strengths of the opposing position or weaknesses of the favoured position, as well as connecting and weighing up opposing arguments. For example, Lara (opposing) said: "Genetically modified foods would be a great solution for this|" (L685). Benício defended "I'm unfavourable because the production of genetically modified food brings more benefits to the producers than to those who consume it" (L65). Perseu proposed "I'm favourable| But there's also the question of study|" (L247–248). In this way, we believe that the students sought to no longer favour a position, but to construct collective, informed, fair and egalitarian decisions.

However, this conclusion may seem contradictory to Bárbara's actions in excerpt 2 of event 3. As you can see, the student presented her group with evidence indicating that eating genetically modified food causes cancer. Despite knowing the evidence, at the time of the debate the student said that she had found no evidence

of this relationship. In other words, Bárbara was not open to considering evidence or arguments contrary to her position, limiting the collective construction of informed and fair solutions. However, looking at the history of the class, practices and values that were proposed and developed throughout the activities became resources for future investigations and debates. Therefore, we can also think that the way in which Bárbara's colleagues participated in the debate, that is, willing to construct a solution that sought the collective good and not the protection of their beliefs or majority positions, may have become a resource for her in future discussions.

In summary, we can conclude that the instructional contexts experienced in the class became resources for students to position themselves critically, that is, understanding the relevance of using and evaluating scientific and other domain evidence, the collaborative role in decision-making, and the willingness to use such skills to make decisions that seek to support marginalized options, mitigating asymmetric power relations.

Discussion and Final Considerations

This study contributes to the national literature by proposing an analysis of CT, mobilizing relevant references. This is relevant because the construct is often treated as jargon about innovative teaching (Bacon, 2018). This problem is observed in the curriculum documents themselves. Cruz and Güllich (2024) observed that Brazilian curriculum documents, as well as those from other Latin American countries, present discussions related to the importance of promoting CT, but they are rarely referenced, leaving the concept not very explicit or generalized.

By mapping the components of CT in science class interactions, we have provided more clarity on how they can be worked with in the classroom. In our analysis, for example, these components were developed using resources legitimized in the inquiry-based and social-scientific instructional contexts experienced by students throughout the 8th and 9th grades. These contexts favour the development of critical thinking, according to authors such as Cruz and Güllich (2024) and Jiménez-Aleixandre and Puig (2022). Promoting inquiry-based activities and socio-scientific debates connected science to the students' daily lives and generated opportunities to seek collective solutions to the problems under discussion. Scientific (and non-scientific) knowledge could be analysed in terms of how well it could function in a fair, democratic and practical decision-making process (e.g., production of cheaper food, need for information on genetically modified foods for the population).

The students we followed did not present components of critical thinking in their final form, but rather in development. We argue that approaches that have already been consolidated in the area of Science Education, such as Inquiry-Based Science Teaching combined with debates on Socioscientific Issues, are ways for students to use science as one (and not the only) relevant way of conceiving positions, even with its limitations. In this sense, we defend the importance of students, in addition to engaging in activities that

involve solving a problem or taking a critical stance, having opportunities to analyse these processes. Often, explanations are systematized from inquiry-based lessons or solutions are proposed from a socio-scientific debate. However, students must also analyse how these processes were constructed in class, that is, *how* knowledge was constructed and *how* decisions were made (Puig & Jiménez-Aleixandre, 2022). Cruz and Güllich (2024) state that these processes constitute a critical reflection on the students' own training as active subjects in society. This movement would help students to evaluate which domains were used to take a position and how their subjective preferences helped or not in the search for solutions that supported the collective.

Finally, from a methodological point of view, our study also offers contributions, considering the potential of an analysis situated over time. The research, part of a broader ethnographic project, generated a broad data set and allowed us to make statements not only about the interactions that took place in a single lesson, but also to establish relationships with other lessons and activities over two school years (8th and 9th grade). Thus, it was possible to analyse CT as a set of components in classroom interactions, focusing on a more processual perspective of its development.

Despite this wealth of data, the research also has practical limitations that need to be considered. One of them refers to the enormous investment of time in prolonged monitoring of classroom interactions. Video files and other artifacts generate a large volume of files that must be carefully organized and coded, so that there is no risk of losing material or difficulties in analysing it later. This work leads the researcher to a progressive selection of events. By making an initial cut in the database, the next level of analysis depends on the data set obtained at the previous level, and so on. In this way, analysis will always be limited by the samples chosen. This means, therefore, that data may be "lost" or gain little visibility throughout the cuts. However, it is through an iterative-responsive process throughout the history of a group (Castanheira et al., 2001) that interpretations of micro events are legitimized. By going back and forth through a group's own history, we build up evidence for our conclusions. Unlike what happens in many interaction analyses carried out in science classes, the validity of ethnographic research is not based on categorizations or on the researchers' agreement with these categorizations. Reliability is built on the transparency of the research processes, the records built up throughout its construction and the contrastive perspective of the relationships between events established in the analyses (Skuskauskaite, 2019).

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References

Agar, M. H. (1994). *Language shock: Understanding the culture of conversation*. William Morrow.

Allchin, D., Bergstrom, C. T., & Osborne, J. (2024). Transforming Science Education in an Age of Misinformation. *Journal of College Science Teaching*, *53*(1), 40–43. https://doi.org/10.1080/0047231X.2023.2292409

Bacon, C. K. (2018). Appropriated literacies: The paradox of critical literacies, policies, and methodologies in a post-truth era. *Education Policy Analysis Archives*, *26*, 147. https://doi.org/10.14507/epaa.26.3377

Bloome, D., Carter, S. P., Christian, B. M., Otto, S., & Shuart-Faris, N. (2005). *Discourse analysis and the study of classroom language and literacy events: A microethnographic perspective*. Routledge.

Brocos, P., & Jiménez-Aleixandre, M. P. (2022). Social Responsibility and Critical Disposition for Considering and Acting upon Conflicting Evidence in Argumentation About Sustainable Diets. In B. Puig, & M. P. Jiménez-Aleixandre (eds.), *Critical Thinking in Biology and Environmental Education. Contributions from Biology Education Research* (pp. 211–227). Springer. https://doi.org/10.1007/978-3-030-92006-7_12

Castanheira, M. L., Crawford, T., Dixon, C., & Green, J. (2001). Interactional Ethnography: an Approach to Studying the Social Construction of Literate Practices. *Linguistics an Education*, *11*(4), 353–400. https://doi.org/10.1016/S0898-5898(00)00032-2

Cavalli, S. B. (2001). Segurança alimentar: a abordagem dos alimentos transgênicos. *Revista de Nutrição*, *14*(suppl.), 41–46. https://doi.org/10.1590/S1415-52732001000400007

Costa, S. L. R., Bortoloci, N. B., Broietti, F. C. D., Vieira, R. M., & Tenreiro-Vieira, C. (2021). Pensamento Crítico No Ensino De Ciências E Educação Matemática: Uma Revisão Bibliográfica Sistemática. *Investigações em Ensino de Ciências*, *26*(1), 145–168. https://doi.org/10.22600/1518-8795.ienci2021v26n1p145

Cruz, L. L., Güllich, R. I. C. (2024). Um estudo comparativo sobre o pensamento crítico: conceitos, referências e estratégias de ensino e formação de professores de ciências em países latino-americanos. *Investigações em Ensino de Ciências*, *29*(2), 588–620. https://doi.org/10.22600/1518-8795.ienci2024v29n2p588

Danvers, E. C. (2016). Criticality's affective entanglements: Rethinking emotion and critical thinking in higher education. *Gender and Education*, *28*(2), 282–297. https://doi.org/10.1080/09540253.2015.1115469

Feinstein, N. W., & Waddington, D. I. (2020). Individual truth judgments or purposeful, collective sensemaking? Rethinking science education's response to the post-truth era. *Educational Psychologist*, *55*(3), 155–166. https://doi.org/10.1080/00461520.2020.1780130

Green, J. L., Dixon, C. N., & Zaharlick, A. (2005). A etnografia como uma lógica de investigação. *Educação em Revista*, (42), 13–79. https://periodicos.ufmg.br/index.php/edrevista/article/view/45228

Jiménez-Aleixandre, M. P., & Puig, B. (2022). Educating Critical Citizens to Face Post-truth: The Time Is Now. In B. Puig, M. P. Jiménez-Aleixandre (eds.), *Critical Thinking in Biology and Environmental Education: Contributions from Biology Education Research* (pp. 3–19). Springer. https://doi.org/10.1007/978-3-030-92006-7_1

Junges, A. L., & Espinosa, T. (2020). Ensino de ciências e os desafios do século XXI: entre a crítica e a confiança na ciência. *Caderno Brasileiro de Ensino de Física*, *37*(3), 1577–1597. https://doi.org/10.5007/2175-7941.2020v37n3p1577

Kuhn, D. (2019). Critical Thinking as Discourse. *Human Development*, *62*(3), 146–164. https://doi.org/10.1159/000500171

Lapsley, D., Chaloner, D. (2020). Post-truth and science identity: A virtue-based approach to science education. *Educational Psychologist*, *55*(3), 132–143. https://doi.org/10.1080/00461520.2020.1778480

McIntyre, L. (2018). *Post-truth*. MIT Press.

Nunes-Neto, N., & Conrado, D. M. (2021). Ensinando Ética. *Educação em Revista*, 37, e24578, 1–28. https://doi.org/10.1590/0102-469824578

Osborne, J., Pimentel, D., Alberts, B., Allchin, D., Barzilai, S., Bergstrom, C., Coffey, J., Donovan, B., Kivinen, K., A., K., & Wineburg, S. (2022). *Science education in an age of misinformation*. Stanford University.

Pedaste, M., Mäeots, M., Siiman, L. A., de Jong, T., van Riesen, S. A. N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review*, *14*, 47–61. https://doi.org/10.1016/j.edurev.2015.02.003

Puig Mauriz, B., Blanco Anaya, P., & Bargiela, I. M. (2023). Integrar el Pensamiento Crítico en la Educación Científica en la Era de la Post-verdad. *Revista Eureka sobre Enseñanza y Divulgación de las Ciencias*, *20*(3), 3301. https://doi.org/10.25267/rev_eureka_ensen_divulg_cienc.2023.v20.i3.3301

Reyes, S. M. S., & Rozowski, N. J. (2003). Alimentos Transgénicos. *Revista chilena de nutrición*, *30*(1), 21–26. https://doi.org/10.4067/S0717-75182003000100003

Silva, E. P. C., Franco, L. G. & Mendonça, P. C. C. (2024). Ensino de Ciências por Investigação e Questões Sociocientíficas em Sala de Aula: Conexões a Partir da Análise de Práticas Epistêmicas. *Revista Brasileira de Pesquisa em Educação em Ciências*, e47892, 1–29. https://doi.org/10.28976/1984-2686rbpec2024u95123

Silva, E. P. C., Oliveira, S. G., & Franco, L. G. (2023): Evaluation of knowledge in science lessons: an analysis of epistemic practices in an 8th grade classroom. *International Journal of Science Education*, *46*(5), 462–484. https://doi.org/10.1080/09500693.2023.2244121

Silva, M. B. e, & Sasseron, L. H. (2021). Alfabetização Científica E Domínios Do Conhecimento Científico: Proposições Para Uma Perspectiva Formativa Comprometida Com A Transformação Social. *Ensaio: Pesquisa em Educação em Ciências*, *23*, e34674, 1–20. https://doi.org/10.1590/1983-21172021230129

Silva, M. G. L., Marbà-Tallada, A., Bargalló, C. M. (2024). Da leitura da realidade à ação problematizadora: uma análise do nível de consciência no desenvolvimento do pensamento crítico. *Revista Brasileira de Pesquisa em Educação em Ciências*, *24*, e51094, 1–35. https://doi.org/10.28976/1984-2686rbpec2024u795829

Sinatra, G. M., & Lombardi, D. (2020). Evaluating sources of scientific evidence and claims in the post-truth era may require reappraising plausibility judgments. *Educational Psychologist*, *55*(3), 1–12. https://doi.org/10.1080/00461520.2020.1730181

Skuskauskaite, A. (2019). Constructing transparency in designing and conducting multilayered research in science and engineering education – potentials and challenges of ethnographically informed discourse-based methodologies. In G. J. Kelly, J. Green (Eds.), *Theory and methods for sociocultural research in science and engineering education* (pp. 234–255). Routledge.

Spradley, J. P. (1980). *Participant Observation*. Holt, Rinehart and Winston.

Wardle, C., & Derakhshan, H. (2018). Thinking about 'information disorder': formats of misinformation, disinformation, and mal information. In C. Ireton, J. Posetti (Ed.), *Journalism, 'fake news' & disinformation: handbook for journalism education and training* (pp. 44–55). UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000265552

Yunta, E. R. (2013). Temas éticos na investigação internacional com alimentos transgênicos. *Acta bioethica*, *19*(2), 209–218. https://doi.org/10.4067/S1726-569X2013000200005

Zeidler, D. L., Sadler, T. D., Applebaum, S., & Callahan, B. E. (2009). Advancing reflective judgment through Socioscientific Issues. *Journal of Research in Science Teaching*, *46*(1), 74–101. https://doi.org/10.1002/tea.20281

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