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SCIENCE TEACHERS TRAINING IN THE POST-TRUTH ERA: THE ROLE OF DIALOGUE AS A MEDIATING PRINCIPLE OF THE PEDAGOGICAL PROCESS

Formar professores de ciências na era da pós-verdade: o papel do diálogo como princípio mediador do processo pedagógico

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Abstract

In the present work, we analyzed different types of mediation mobilized in a first semester Physics degree class over a four-week teaching unit. The research deals with Bruno Latour's Science Studies and, above all, with his concept of mediation, in its four variations – interference, composition, folding of space and time and delegation. We mobilize ethnographic tools for data construction and analysis; based on the use of questionnaires, participant observation of lessons, collection of artifacts produced in the unit, as well as records of discursive interactions. Our results indicate that the composition of students with support materials, such as semiotic instruments typical of Physics, as well as videos that discussed the topic, allowed for a complexification and expansion of the participants' performances in both their epistemic and political dimensions. Furthermore, the use of questioning as a pedagogical principle by the teacher, to the detriment of directive instruction, expanded the opportunities for undergraduate students to exceed their original performances and the performances suggested by the teacher himself, which highlights the potential of the question as a mobilizer of new agencies. In this way, our work points to three conclusions for the promotion of a pedagogical process in the post-truth era: i) conceptual teaching and learning in a way intertwined with a sociopolitical discussion, ii) the appreciation of teachers as critical intellectuals, and iii) the privilege of questioning as a tool to promote dialogue in the classroom.

Keywords: Post-truth; Teacher training; Flat-earthism.

Resumo

No presente trabalho, analisamos formas de mediação mobilizadas ao longo de uma unidade didática sobre formato da Terra em uma turma de primeiro semestre de licenciatura em Física. A pesquisa dialoga com os Estudos das Ciências de Bruno Latour e, sobretudo, com seu conceito de mediação, em suas quatro variações – interferência, composição, entrelaçamento de espaço-tempo e delegação. Mobilizamos ferramentas etnográficas para construção e análise de dados; a partir do uso de questionários, observação participante das aulas, coleta de artefatos produzidos na unidade, bem como registros de interações discursivas. Nossos resultados indicam que a composição dos estudantes com materiais de apoio, como instrumentos semióticos típicos da Física, bem como vídeos que discutiam o tema, permitiu uma ampliação das performances dos participantes tanto em sua dimensão epistêmica quanto política. Ademais, o uso de questionamentos como princípio pedagógico pelo docente formador, em detrimento de uma instrução diretiva, ampliou as oportunidades para que os licenciandos excedessem suas performances originais e as performances sugeridas pelo próprio docente, o que evidencia o potencial da pergunta enquanto mobilizador de novos modos de ação. Dessa forma, nosso trabalho aponta três conclusões para a promoção de um processo pedagógico na era da pós-verdade: i) o ensino e aprendizagem conceitual de modo entrelaçado a uma

discussão sociopolítica, ii) a valorização do docente enquanto intelectual crítico, e iii) o privilégio do questionamento enquanto ferramenta promotora do diálogo na sala de aula.

Palavras-Chave: Pós-verdade; Formação de professores; Terraplanismo.

INTRODUCTON

Education is always an ontological-political process, since any curriculum and educational event is organized so that, in the end, an ideal being can be formed (Silva, 2010). This ideal being, in turn, reflects the values, desires and conceptions of an entire social and knowledge organization. In other words, education responds[1] to specific political conceptions and assumptions, as well as being, or should be, responsive to the concrete social context in which it is established. In this sense, Freire's maxim that education is always aligned axiologically and politically is recognized (Freire, 2013).

Based on this assumption, teacher training is also an important field of dispute, since what is at stake is which training and curriculum model, ultimately, which ideal being is to be formed. The training models described by Contreras (2012), for example, highlight the epistemological-political abyss that exists between a technical rationalist training model and a critical intellectual one. While the first makes the teaching career precarious by relegating the teacher to the role of an implementer of a pre-established curriculum, the second places the teacher at the center of the pedagogical process, recognizing him/her as a true intellectual, a creative author and a responsible/responsive agent of the world in which he/she lives. In this way, these models can be understood as aligning with liberal (technical rationalist) and progressive (critical intellectual) assumptions. These tensions have also been reflected in the training of science education teachers in Brazil (Rezende & Ostermann, 2020).

In recent years, however, in the national and international political-epistemic scenario, questions have been raised about whether or not we have experienced a significant rupture in the political organization to which we are accustomed. In particular, the phenomenon of post-truth, institutionalized in 2016, when the Oxford Dictionary chose the term as its word of the year (Oxford Dictionary, 2016), has pressured a review of our most fundamental concepts about politics and knowledge.

Post-truth refers to scenarios in which well-established propositions are purposefully confused with alternative propositions in the public sphere, usually in matters of economic interest or that cross different dimensions of the exercise of power (Lima, Vazata, Moraes, Ostermann, & Cavalcanti. 2019). Thus, post-truth is not a purely epistemic phenomenon, nor is it a simple denial of science. It is the artificial creation of controversies on relevant topics that confuse the population. Events related to this phenomenon have unfortunately been witnessed several times throughout the COVID-19 pandemic (Moura, Nascimento, & Lima 2021).

Bruno Latour, a French philosopher, in his book “Where to Land? How to Orient Yourself Politically in the Anthropocene” (Latour, 2020) advocates the notion that post-truth, with the election of Donald Trump as president of the United States, inaugurates a new political scenario, which must overcome the old left/right or liberal/progressive dichotomy. This is because we now have a pole “out of this world”, contemplated by absurd discourses and proposals, versus the defense of articulated propositions that lead to the preservation of the Earth, the soil, and life, the “terrestrial pole”. For Latour, then, post-truth is a new phenomenon that creates an irreparable split in our maps and social organizations. This proposition is not unanimous, being, for example, contested by Jasanoff and Simet (2017).

Latour (2004) also argues that, in the current scenario, what exists or does not exist is the object of the process of dispute between different collectives, while the very existence of certain entities symmetrically affects social organization. This recognition gives rise to the notion that it is no longer enough to talk about politics, but to think about cosmopolitics – a term derived from the philosophical works of Isabelle Stengers (2018; 2010).

Regardless of whether we agree with the fundamental rupture proposed by Latour, it is undeniable that, after the pandemic, we have seen the power of anti-science movements in our society, the proliferation of false discourses, and the systematic attack that universities and science have been suffering worldwide

[1] In this work, the terms “respond” and “responsive” are being used in the sense given by Bakhtin (1981). In this sense, every statement actively responds to previous statements, not only in the field of culture, but also in an ethical way. Being responsive is being responsible, making choices and taking an axiological position in relation to culture and life.

and, especially, in Brazil, during the government of Jair Bolsonaro. This recognition led, for example, to the publication of the Brazilian journal "Caderno Brasileiro de Ensino de Física" in 2020[2], a special issue on Post-Truth. The international journal Science & Education[3], in turn, in 2021, made a special call on trust in science and science education. Thus, it has recently become quite clear that it is necessary to rethink science education for the age of misinformation. The US government, together with Stanford University and several researchers, released a recent report on this topic (Osborne, Zucker & Pimentel, 2023), and studies have addressed this concern (Allchin, 2023; Osborne & Pimentel, 2023; Moura, Alsop, Camel, & Guerra, 2023).

In the context of Brazilian literature, Rosa, Alves-Brito and Pinheiro (2020) argue that hegemonic science itself is a state of post-truth that ignores knowledge produced outside the dominant scientific logic. Pivaro and Girotto Júnior (2020), in turn, when analyzing the role of scientific denialism in the sociopolitical context since the 1950s, point out that the phenomenon of post-truth is not new to the scientific community, as it is an already known form of denialism, while Messeder Neto and Moradillo (2020), from the historical-critical materialist perspective, argue that post-truth is a reflection of capital and class society. According to this perspective, truth becomes a nuisance to the ruling classes, as it begins to provide subsidies for the liberation of the masses and, in this way, the bourgeoisie, while valuing and using unlimited achievements of science and technology, encourages the masses to religion and mysticism. Despite the different perspectives on the same phenomenon, there is a relatively articulated movement among such researchers to defend pedagogical work that involves post-truth in the context of science education (Pivaro & Girotto Júnior, 2020). In this sense, it may seem reasonable that an "overcoming" of post-truth can occur from scientific knowledge. However, Ranniery, Telha and Terra (2020) draw attention to the fact that criticism of post-truth cannot culminate in the defense of an Enlightenment science education project. These authors perceive in Isabelle Stengers' cosmopolitical proposition an ethical-political way of conceiving science teaching for the post-truth era, since cosmopolitics not only questions the supposed universality and superiority of scientific knowledge over other forms of knowledge, but also invites us to conceive of science based on its practices, relationships, and processes.

In this way, the current scenario causes previously well-established issues to be debated again and topics such as the shape of the Earth – which has been considered a consensus in the scientific community and beyond for centuries – to be explored in the context of Science Education (Bondezan & Kawamura, 2022; Hilger & Mariniak, 2022; Marineli, 2020; Martins, 2020). Martins (2020), who analyzes the phenomenon of the flat-earther movement based on the National Flat Earth Convention, questions whether science teachers are prepared to deal with this issue and argues for the need for the area to dedicate attention to it. Marineli (2020), in turn, highlights the importance of science teachers appropriating the flat-earther phenomenon and the need to reflect on denialist movements in educational processes. Exploratory studies in initial teacher training indicate that it is necessary to discuss the topic of flat-eartherism in the context of higher education in order to prepare future teachers to deal with this topic in the classroom (Hilger & Mariniak, 2022) and highlight the importance of establishing collective discussions on the topic (Bondezan & Kawamura, 2022).

Although we have identified a growing number of studies on the topics of post-truth, scientific denialism and misinformation, there are still few studies that are dedicated to analyzing data in the classroom context. That is, although we have made progress in theorizing about these phenomena and their relationship with science education, we need to move forward in understanding how such issues can present themselves in the daily classroom (in Basic Education or in teacher training) and what possible effects they can produce. In this sense, we question how teachers in initial training position themselves in relation to socially controversial topics, how they construct new knowledge based on such issues, what resources they mobilize to position themselves, and what pedagogical proposals are powerful throughout their training process.

Thus, considering the scarcity of empirical studies on the approach to the topic in the classroom context, we sought to contribute to the field of research through an investigation developed throughout a discipline at the beginning of a Physics undergraduate course, in which a post-truth theme was explicitly addressed. Specifically, we analyzed interactions and activities in a teaching unit designed to incorporate three didactic axes (Allchin, Andersen, & Nielsen, 2014): (a) historical aspects of scientific knowledge; (b) activities with open problems that demanded student engagement and collaboration; (c) reflections and debates on a socio-scientific theme. In this unit, together with the specific contents of the discipline, flat-earther movements

[2] Available at https://periodicos.ufsc.br/index.php/fisica/issue/view/3108. Accessed on November 16, 2024.
[3] Available at http://www.eshs.org/2020/10/26/call-for-papers-science-and-education-why-trust-science-and-science-education/. Accessed on November 16, 2024.

were addressed while discussing the use of trigonometry to measure distances on Earth and in the Solar System.

The aim of this study is to investigate how the performances of the class-teacher collective varied throughout the unit in the face of different mediation mechanisms (Latour, 2001) present in the activities related to flat-earthism. To achieve this, we constructed answers to the following research questions: (i) throughout the process, what mediation mechanisms – in the sense attributed by Latour (2001) – occur in the classroom collective? (ii) How do the different types of mediation alter the discursive performances of students and teachers about the role of teaching physics/science in basic education? Based on these answers, we propose a dialogue with the theoretical-methodological framework mobilized and with the specialized literature in the area of education and science education, in order to reflect and generate notes on teacher training in the post-truth era.

THEORETICAL FRAMEWORK: BETWEEN DIALOGUES AND MEDIATIONS

In this study, we use the concept of mediation as a theoretical lens. Different notions about mediation are discussed and proposed in the areas of Education and Psychology to describe teaching-learning processes and the cognitive development of individuals. Thus, the concept assumes certain meanings according to different perspectives.

Wertsch, for example, based on Vygotsky's reading, associates the term with the *"use of auxiliary means in solving psychological problems"* (Pereira & Lima Jr, 2014, p. 526). Wertsch (1991) emphasizes that human beings act in a mediated way. For example, a person's capacity for action alone is different from his capacity for action with a hammer. What he is capable of doing and, in fact, does, changes through the mediation of material and symbolic tools. Thus, if we define a person by what he or she does, the use of mediational means is so important that we should not speak of the man with a hammer, but of the man-with-a-hammer, this new actor that emerges from the association with the mediational means.

In the specific case of cognition, we can see that our ability to do math increases if we have paper and pencil. Or we are able to remember the order of a series of events if we can take notes throughout the process. This leads to the idea that cognition is something that extends outside the brain or the body of the subject and becomes an activity shared by a collective.

Wertsch also gives the example of a child who forgot where he or she left his or her toy and asks his or her father for help. The father then begins to ask him or her a series of questions about where the child was and where he or she could have left the toy. Then the child runs away, because he or she remembered where he or she had left it. In this case, neither the child remembered where the toy was on his or her own, nor could the father have known where the toy was. The father's mediation, through questioning, allowed the desired memory.

Using this concept, Pereira, Ostermann and Cavalcanti (2009) indicate that, in an activity with a virtual Mach-Zehnder interferometer, when students discuss questions in pairs, the questions from the "less capable partner" make the answers from the "more capable partners" increasingly more complex and precise. In other words, in addition to showing that the "more capable partner" benefits from the presence of a "less capable partner", the article also exemplifies how mediation through questions improves cognitive activity, so that we cannot talk about each student individually, but rather about the partnership of students answering the questions. An important implication that we can interpret for science education is that, from a sociological perspective like this, the actor to be investigated is no longer each student individually, but the collective of students and their materials (software, calculator, paper, pencil) – it is the collective of humans and mediational means that form the subject of a shared action.

Another concept of mediation, which we align ourselves with and mobilize in this study, was proposed by Bruno Latour. We adopted Latour's propositions (2001), because his concept of mediation emphasizes the changes in performances generated by the processes of interaction between human and non-human actors. In this conception, the association of humans and non-humans generates new actors with actions that the previous actors did not have in isolation. This is particularly relevant in this study, considering that we were interested in investigating changes in the performances of the class-teacher collective throughout a formative process. More specifically, these interaction processes that can be interpreted as mediations in the sense given by Bruno Latour have four meanings (Latour, 2001): interference, composition, folding of space and time

and delegation. These categories were useful insofar as they helped us characterize forms of interactions of the class-teacher collective throughout the classes analyzed.

The first type of mediation is what Latour calls **interference**. Two agents (human or non-human) in isolation have their own action programs in advance. When they meet, one agent may act in the direction of the other's program, or, mainly, a third action program may be created, with new objectives and performances. In every encounter, there is uncertainty and fluctuation about what the new action program established from the interaction will be, which Latour calls a translation process (Latour, 2001). From the point of view of cosmopolitical metaphysics, this is equivalent to recognizing that actors are always formed by the network of interaction with other actors and, therefore, the association of two new actors creates a new actor, with new performances and properties.

Translating this to the context of educational research, an example where this mediation appears is in the meeting between the teacher and the class. Each student has their own interests, objectives and performances. The teacher, in turn, also has their own pre-defined action program. From this meeting, the teacher can encourage the entire class or some students to follow their program. Conversely, the teacher may be encouraged by the class and do something completely different from what was planned. Or, something new and unexpected may emerge from this meeting, and the pedagogical path is developed through mediation between the teacher and the students, in which the established action program arises from the interests, needs, demands and tensions imposed by the different actors.

The second type of mediation is **composition**, normally used to talk about the relationship between humans and non-humans or even the relationship between non-humans. An initial agent may have an initial action program, which encounters difficulties or challenges. From there, it can mobilize other agents, such as tools, changing its action program. Thus, action is not a property of humans alone, but of the association of humans and non-humans. Action must be attributed to the network as a whole.

This form of mediation can also be understood in the pedagogical context. Someone's ability to solve math problems is not the same with or without a scientific calculator. Our ability to write a text, positioning ourselves on a specific topic, changes if we have available materials on the subject; the availability of specific instruments may or may not facilitate our ability to perform certain tasks. In this sense, the capacity for action, understanding, communication and, therefore, learning itself are not properties of the human alone, but of the collective of humans and non-humans mobilized in the network and, therefore, learning, communication, appropriation and mastery should be analysed as a collective and not as an individual human.

The third type of mediation is the **folding of time and space**. In this case, a single agent, on certain occasions, reveals itself to be a collective of agents. Latour (2001) discusses, for example, how a projector, which – originally – goes unnoticed, as if it did not even exist, when it breaks down in the middle of a presentation, suddenly becomes a set of parts, associations, demanding technique and mobilizing knowledge. Now, there is a set of technicians and parts around the projector, it is no longer just one, a black box opens. Later, this black box is closed and, with luck, the projector starts working again and goes unnoticed. The processes of opening and closing black boxes are associated with this third type of mediation. Again, in the educational field, we can think about the very elaboration of a given concept in the didactic context. When a book teaches the conservation of energy as a postulate, or presents only an equation, it is presenting a black box, which hides centuries of discussions, debates, controversies and disputes. On the other hand, the teacher can choose to present historical texts and, suddenly, that single actor becomes a complex and tangled network. Students can dive into this network and even debate the relevance and power of the different perspectives. In the end, they hide everything again in an equation and start to solve a series of exercises using this principle (closing the black box).

Finally, the last meaning of mediation involves the transposition of the boundaries between signs and things, which Latour calls **delegation**. In this case, Latour discusses how a material object, or technological apparatus, is an element that possesses, reifies, or materializes meaning, even though it is not in the discourse. In this case, he mentions the example of a speed bump. At some point, it was realized that cars in that area should slow down to avoid running over someone. The legislators then put up a speed bump. In this case, the will of the subjects is delegated to the concrete block, while at the same time there is a translation of the appeal to the moral ideal of drivers not to run over anyone to the selfish appeal of not wanting to break their car. An example of this type of mediation in the educational context refers to the pedagogical and curricular proposals of a school. A school can, for example, receive laboratory materials or information and communication technologies from the education department. Even though these are material objects, their

presence in the school refers to a public policy that comes from an authority higher than the school itself and that "tells" what teachers should do.

Thus, these four forms of mediation help us understand the different types of associations and movements that relationships between humans and non-humans can imply, serving as a lens through which we can also think about events in the classroom. And, in the specific case of this research, it is important to know what types of mediation are present and how they contribute to or hinder the pedagogical process.

THEORETICAL-METHODOLOGICAL TRAJECTORY

This study was developed by two research groups from two Brazilian universities in the Southeast and South regions of the country. The entire research design and data analysis were organized collectively by all members involved, and the implementation of the activities and data collection took place in the undergraduate Physics course at a Brazilian federal university in Rio Grande do Sul, in an introductory Physics discipline, in the first semester of the 2023 academic year.

This course was created in a recent curricular reform that the undergraduate course underwent in the context of adapting the program to public policies for teacher training[4]. The course aims, first and foremost, to contribute to the integration of specific Physics themes with broader pedagogical and epistemological discussions, strengthening the teaching identity. Furthermore, its syllabus was designed to strengthen students' sense of belonging and their perspective on the curriculum – factors that significantly contribute to the decision to remain in the course (Heidemann, Moraes, & Giongo, 2020). There is an institutional expectation, therefore, that this discipline will contribute to reducing the dropout rates of students in this degree, while also addressing concepts that will help students in future disciplines, such as calculus and Physics 1.

The starting point of the research was the proposal of the professor of the discipline, who is a researcher in the area of history, philosophy and teaching of Physics, to develop a teaching unit, to be implemented in the first three weeks of class, to address the topic of post-truth and contemporary sociopolitical discussions. Since the professor would need to revisit discussions on trigonometry and mechanics – it was immediately proposed that the flat-earther movement be taken as the theme of the unit. For data collection and analysis, we adopted a qualitative research perspective based on the Actor-Network Theory (ANT) (Latour, 2005). We adopted data collection procedures and instruments common to ethnographic studies in the classroom[5]: participant observation, observation diary, audio recording and transcription of meetings, activity logs, photos, and use of questionnaires (Green & Bloome, 1997; Frank, 1999).

In the data collection process, we conducted observations and records based on questions that are typical of ethnographic studies. The initial questions were important in providing a broad description of the events in the classroom. What is happening here? Who can speak and who cannot in the classroom events? What is valued in the interactions? Which actors/actants are involved and how do they interact? These questions are examples of initial questions that guided our observations and were refined and detailed, based on more systematic contact with the data, until the elaboration of our final research questions.

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Still based on the ethnographic perspective, we sought to start from the events and narratives of the participants themselves, in order to then add theoretical layers to the interpretation of the data, instead of initially starting from a crystallized theoretical conception or formal hypotheses. As Venturini (2010) warns, doing this does not mean adopting the hypothesis of the absence of prior theoretical load. The idea is to initially

[4] Available at: http://portal.mec.gov.br/docman/agosto-2017-pdf/70431-res-cne-cp-002-03072015-pdf/file. Accessed on November 16, 2024.

[5] All ethical commitments were respected and, before the beginning of the research, the participants signed an Informed Consent Form.

keep the questions more open so that different theoretical conceptions can be discussed until it is decided which concepts would be most relevant for analysing the process of interest in the study.

Thus, the interpretative process is theoretical from beginning to end, and it demands an effort of discussion and dialogue between the researchers until it converges on the analysis performed. Our initial questions converged on the questions about mediation presented in the introduction of the text. The perspective adopted for data analysis, therefore, goes towards a description and interpretation capable of highlighting different types of mediation throughout the activities, as well as the changes in the actors' performances generated by such mediations.

The teacher, in dialogue with the other members of the research group, created six classes with the objective of discussing the shape of the Earth, the history of the discussion about this shape, the rise of the flat-earther movement, the political aspects of this movement and the political role of science education in the contemporary scenario. The teacher's concern when preparing the unit was the following: (1) to address trigonometry concepts that will be important in other disciplines; (2) work with the history of science to help in the learning of concepts; (3) develop activities that allow students to engage in the learning process; (4) foster the teaching identity of teachers in training, highlighting the importance of science education for the contemporary scenario. With this in mind, the teaching unit was developed and is summarized in Chart 1.

Chart 1 – Summary of the analyzed teaching unit.

Lesson	Description	Homework
1	Presentation of the subject and introduction of the teaching unit. Application of initial questionnaires.	Read a historical text about the shape of the Earth and Eratosthenes' method. Students answered questions about the interpretation of the text.
2	Trigonometry review. Practical task: measure the height of the Physics Institute building using trigonometry concepts.	No homework.
3	Discussion of homework answers. Students were divided into smaller groups to solve trigonometry questions and then presented their solutions to the entire class.	Watch a video selected by the teacher with arguments for flat-earthism and the round Earth. Write down all the arguments and comment on them..
4	List of trigonometry exercises and measurement calculations throughout planet Earth.	No homework.
5	Debate about the shape of the Earth. The class was divided into four groups. Two groups were supposed to defend the flat Earth and two groups were supposed to defend the round Earth.	No homework.
6	Writing a reflection on the activity. Writing an opinion on the colleague's reflection (in pairs). Discussion with the whole class about the activity.	No homework.

Source: the autors.

The unit was implemented in the aforementioned discipline in the first semester of 2023. There were 16 students enrolled in the class; but – since the first class – only 13 students participated in the meetings. In addition to the research professor, the discipline had a teaching intern, a doctoral student from the research group, who, in addition to helping with the preparation and implementation of the activities, kept the logbook for all classes, recorded and transcribed the collective discussions, recorded the students' productions on the whiteboard with photos, and digitized and transcribed the answers to activities done by hand by the students.

The thirteen students were from the metropolitan region of the state of Rio Grande do Sul, with the majority having studied at a state high school, followed by students from private and federal schools. In particular, for the study from an ethnographic perspective, it is important to emphasize that this group, despite

having just met (since these were their first weeks at university), shared a common understanding related to Physics teaching (as we will discuss in more detail in the results section), namely, the experience of teaching Physics in an expository manner, assessed by tests, with the objective of preparing for the entrance exam. Thus, the students shared similar notions about the objectives, practices, and instruments typical of the Physics classroom.

After implementing the entire unit, collecting and organizing the data, the research groups began to discuss and interpret what was collected. Based on this reading, the lived experience, and the dialogue with the theoretical frameworks presented, the researchers arrived at the proposed research questions and, above all, decided to develop the analysis based on Latour's (2001) concept of mediation.

In the next section, we present the report of the activities carried out throughout the teaching unit and the data collected to subsequently provide an interpretation of the entire pedagogical process, from the development of the teaching activity to its completion, based on the notion of mediation proposed by Latour (2001). In this process, we characterize the collective that makes up the class, and we will present the different actors, human and non-human, their associations and the changes in performances based on the different mediation events, which will allow us to answer the research questions presented in the introduction to this article. With this analysis, we will then be able to outline reflections on teacher training in the post-truth era.

TEACHING UNIT AND COLLECTED DATA

Class 1 of the teaching unit was divided into two parts: the first part involved the application of initial questionnaires, while the second half of the class was dedicated to the introduction of the subject and discussions about science teaching and sociopolitical issues. In order to identify the possible existence of elements shared by the class that could characterize it as a network, we used questionnaires in which students were asked to report their previous experiences with Physics (as elementary and high school students), their conceptions about Physics and about the teaching of this subject. Students were also asked about the shape of the Earth and the flat-earth movement, and were asked to provide arguments that were capable of justifying the globe-Earth model and refuting the flat-Earth theory. The questions asked are available in Annex 2[6].

In this first part, the students did not detail their experiences with Physics and provided only generic answers such as:

> *Student 10: "reasonably good",*
> *Student 12: "it was great, my teacher is wonderful",*
> *Student 5: "good"*
> *Student 6: "always very positive. I enjoyed the lessons".*

The answers about the role of physics in Basic Education and in training for citizenship demonstrate an instrumentalist view of scientific knowledge and a linear association between science, technology and progress.

> *Student 1: "For personal and other people's safety, development of new technologies, etc."*
> *Student 4: "It helps people understand and solve simple problems in everyday life."*
> *Student 9: "We use Physics all the time in our daily lives. So it's important that we know how to calculate simple things like speed and distance, which shows how long it takes us to get somewhere. It's also important to know about electricity and, for example, how much electricity is used to take a shower."*
> *Student 10: "It can help citizens create new technologies for the good of all".*

When asked about the shape of the Earth and what arguments would justify such shape, part of the class looked for empirical and phenomenological arguments to justify the round Earth, such as:

> *Student 5: "the appearance and disappearance of caravels on the horizon; eclipses; gravity",*

[6] Annexes published in Harvard Dataverse: https://doi.org/10.7910/DVN/KZET41.

> *Student 13: "the Moon orbits planet Earth and depending on its phase it can be more visible during the day. The ship disappears on the horizon due to the curvature of the Earth",*
> *Student 11: "There would be no difference in temperature if the Sun always followed the same path. Another proof is that, while it is day on one side, it is dark on the other. If the Earth were flat, theoretically, everything would be illuminated or dark at the same time."*

A portion of the students, who did not know how to justify it, indicated great confidence in science and institutions:

> *Student 4: "I don't know if that's the case [the shape of the Earth], I just trust scientists/physicists",*
> *Student 1: "Through scientific publications that prove this, images...",*
> *Student 13: "The Earth is round, because through many years of study and countless photos, videos and live broadcasts, I can believe that the Earth is not flat."*
> *[...] that's what I learned at school";*
> *Student 6: "The photos and videos taken from the ISS and other satellites are more than enough proof..."*
> *Student 12: "I can't prove that the Earth is round, but that's all that makes sense; it's round like any other celestial body because of gravity. Furthermore, images captured from high altitudes show the curvature of the Earth on the horizon."*

The flat-earther movement, in turn, was associated by the group with both a lack of knowledge on the subject and insufficient scientific education:

> *Student 10: "Lay people don't understand and don't seek to understand"*
> *Student 8: "[the flat-earther movement] exists because of a flawed education system. Causing controversy on the subject and, consequently, conspiracy theories".*

Regarding political and ideological movements and the phenomenon of disinformation and fake news:

> *Student 3: "The reason some people believe the Earth is flat is not because it is the most logical explanation, but because this theory is connected to other conspiracies, some of which are very radical, racist, anti-Semitic, etc."*
> *Student 7: "There shouldn't be [people who believe in flat-earthers], but rather because of conspiracy theories and fake news."*
> *Student 1: "I believe these are theories that gain strength over time, motivated by a lack of knowledge and the spread of false information."*

Following the schedule shown in Chart 1, in the second class of the teaching unit we sought to review the concepts of trigonometry and encourage students to put the concepts into practice. Thus, on that day an activity was proposed in which students had to develop a strategy to measure the height of the building of the University's Physics Institute. Students were given whiteboards that they could manipulate and pens with which they could sketch their ideas (Figure 1). After discussions among the groups of students, with the help of the teacher and the intern, a common methodology was chosen that would be used by all groups and that, according to the concerns regarding the imprecision of the method, would be repeated at least 3 times by each group.

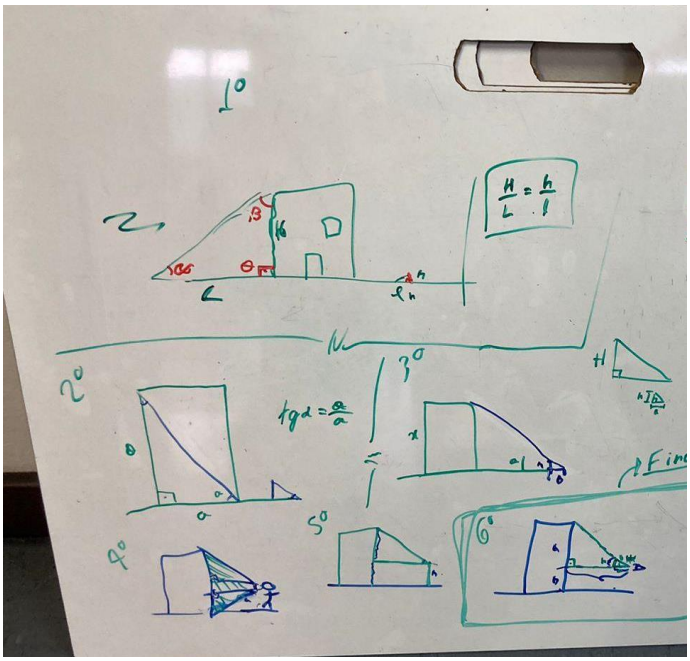

Figure 1 – Board with an outline of the strategies developed by one of the groups of students.

The chosen strategy depended on the aid of an object (notebook, pen, cell phone, tape measure), an observer and basic trigonometry concepts. Based on an adaptation of the Pythagorean Theorem, the students used different objects to measure the height of the building.

Each group chose a student, who stood in front of the building, at a known distance from its base, closed one eye and placed different objects in front of him/her so as to block his/her view of the entire length of the building. The students also measured the height of the object used and its distance from the observer's face, in addition to the height of the observer himself/herself. Following this methodology, each group performed approximately 9 to 12 measurements using different objects, distances from the building and observers. They arrived at values that were close to each other (9.08m to 10.2m).

In class 3, the class dedicated itself to solving exercises related to trigonometric calculations. The students were divided into groups to work on these issues. The whiteboards were once again distributed among the groups so that students could share their ideas. The teacher took turns going from group to group, helping with questions about the questions, trigonometry concepts, and using a scientific calculator in exercises involving angles. In this class, in addition to the calculations, the students and the teacher discussed a historical text entitled "How did the Earth become a globe?"[7] The text included examples of flat-earther proposals defended centuries ago, as well as a discussion of aspects of the construction of science, the difference between observations, data, models, and the influence of human senses in collecting this data. At the end of class 3, the teacher asked the students, as homework, to watch a video in which a group of flat-earthers are taken to the São Paulo Planetarium to discuss issues related to the shape of the Earth with the director of the institution, who, in turn, has a degree in Physics[8]. In this activity, students were asked to write down the arguments used by the flat-Earth group and the scientist, discussing their quality (explaining them, criticizing them or agreeing with them).

In class 4, the class continued working on solving trigonometric exercises, this time individually and still using calculators. In class 5, after the answers to the video were submitted, the students were divided into small groups to share their arguments about each model, and then the class was divided into two large groups. Half of the class was asked to defend the flat-Earth model and the other half, the globe-Earth model. The transcript of the discussion is available in Annex 3[9].

In the last class of the unit – class 6, the students carried out an individual activity: writing a short text about the role of science teaching. Then, they sat in pairs and each classmate read and commented on their

[7] See Annex 1. Annexes published in Harvard Dataverse: https://doi.org/10.7910/DVN/KZET41.
[8] Available at: https://www.youtube.com/watch?v=BXU3R_gvsoQ.
[9] Annexes published in Harvard Dataverse: https://doi.org/10.7910/DVN/KZET41.

partner's text. This activity was adopted as a way to help encourage the raising of ideas and the subsequent oral discussion. In their essays, students used arguments such as the development of “critical thinking” and the “ability to question the world,” but they also highlighted the potential of science education in combating “misinformation,” “denial movements,” and “fake news,” and its ability to prepare individuals for “decision-making” and “problem-solving.” The teacher then opened the discussion by asking each student to make a brief reflection for the entire class. The discussion was recorded and its full transcript is available in Annex 4[10].

When, in the final discussion, the teacher asked the class once again about their experience with physics education at school, the answers were completer and more confirmed the hegemonic teaching they had received. Some exemplary sentences are highlighted below.

> *Student 4: Regarding the physics education for me, I think it was a more traditional education.*
> *Student 2: My physics education, because we had a lot of content in a very short time, ended up being very traditional, it was calculus, there wasn't much explanation of how it could be applied. Although physics is an explanation of the physical world, it wasn't really just a drawing on paper.*
> *Student 3: I think... In my high school, I think it was different because we saw it a little more experimentally, you know, we had a lot of classes with chalkboards, boards and pens, but we ended up having to do some experiments like that, for example, calculating with a little ball and everything, calculating what the value of gravity was, for example, and that kind of thing, so I think that was always more interesting.*

Regarding the role of Physics in Basic Education, the responses again indicated an instrumentalist and scientific position:

> *Student 4: "[...] the purpose of teaching physics for me would be to make people understand how the world they inhabit works, how things happen around us so that you can have an insight, for example, so that you can understand the relationships between phenomena, or even between people. I think that having this curiosity, or awakening this curiosity for me, in people, would be the purpose of physics, right."*
> *Student 2: "If you understand the core of physics, if you see its applicability in the world, in the technology where we live, you have greater confidence in scientific methodology, and scientific methodology is present in all sciences. So, understanding this, you develop a greater critical sense for pseudosciences, and that was kind of the conclusion we reached."*
>
> *Student 12: "[...] we see physics as a gateway to creating critical thinking in human beings, and that's basically what he said, what we wrote. That people use physics, it encourages them to think and understand things, and you can apply this to all areas of life."*

However, as the teacher raised questions throughout the debate, new elements were brought up in the students' discourses, which we analyse in detail in the next section.

RESULTS AND ANALYSIS

Throughout this section, we present an analysis of the data. We elucidate the types of mediations involved in the didactic unit analysed, as well as the role of these forms of mediation in the changes observed in the pedagogical process.

Initial actors

The events analysed involve the encounter of two main actors: the teacher and the group of students. As discussed by ANT, each actor is, in itself, a network, and each network is an actor. How deep and extensive the characterization of an actor-network is depends on the interests and objectives of a research.

Firstly, the teacher acts, throughout the didactic unit, as a representative of the institution, which planned the discipline to combat dropout and foster the teaching identity of teachers in training, in addition to promoting engagement and conceptual learning. Furthermore, the teacher, as a member of a research group, raises concerns about post-truth and scientific denialism. Therefore, he was delegated the function of fulfilling the network's action program. This delegation took place between humans and the professor represents the interests and desires of this network (Callon, 1984). In this sense, he himself translates the original action

[10] Annexes published in Harvard Dataverse: https://doi.org/10.7910/DVN/KZET41.

programs conceived by the two groups (institution and research group). This translation is, therefore, also the result of interference between the plans of the institution and the research group. It is up to the delegated professor to promote a performance that accounts for and reconciles the proposed plans and interests, as represented in Figure 2.

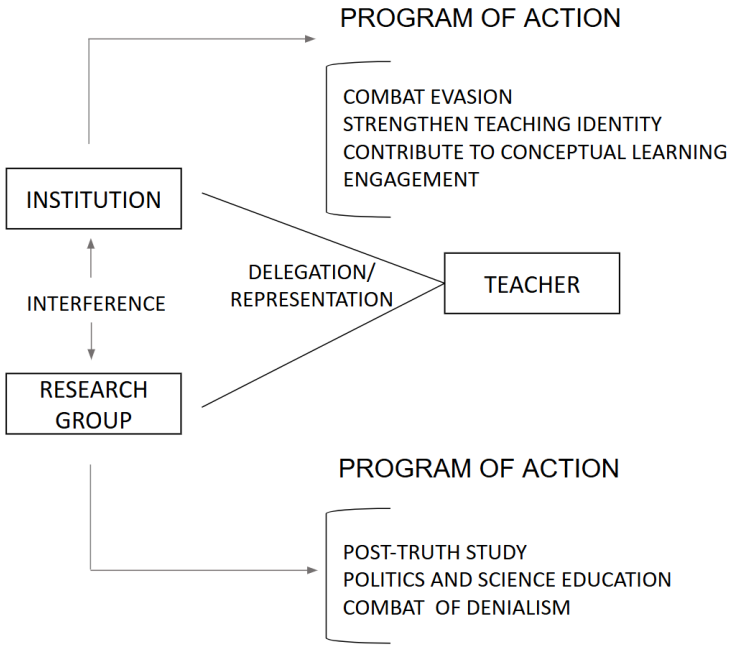

Figure 2 – Mediation processes associated with the teacher's performance in the discipline.

The class, on the other hand, is a network of 13 students. Each student, at some point, may participate as an isolated actor (e.g., when answering an individual questionnaire or giving his/her opinion in a discussion), or may represent a sub-network (e.g., when speaking on behalf of a group of students in an activity), or may represent the class as a whole (e.g., as in debates, when one student says something that everyone agrees with). Furthermore, these students may also be considered members of other networks (their families, communities, religious entities). However, what interests us – from an ethnographic point of view – is to characterize this group as a collective, a stable network. That is, despite having only known each other for a short time when they entered the undergraduate course, these students form a network to the extent that they share common practices, concepts, and values. It was observed, from the initial questionnaires and the reports made by the students in the final discussion, that the class shared the common experience of a Physics teaching that was mostly expository, with discussions far removed from political issues, focused on solving exercises and reproducing experiments. Illustrative expressions of this perception were: "traditional classes", "theoretical", "expository classes". Regarding the assessments, in general, the students reported that they were carried out through tests. Few mentioned experiment reports. Regarding the role of Physics in basic education, the responses indicated a perception by the students of the potential of this area in describing the world, as well as its impact on the development of abstraction and critical thinking.

In this sense, another relevant aspect was the shared perception of the importance of Physics for aspects more related to the individual than to the collective, so that the teaching and learning of Physics can be associated with the formation of individually responsible citizens (Rosa, Lima, & Cavalcanti, 2023) - that is, learning Physics content contributes to the individual insofar as it allows them to make choices that impact their daily personal lives. Other ways of thinking about science teaching and learning in citizenship education could be associated with the education of participatory citizens, who, with scientific knowledge, seek to solve problems in the community in which they live, or citizens oriented towards social justice, who, with knowledge of science, seek to overcome social inequalities and forms of oppression. Some answers in the questionnaire were illustrative of this perception, such as: "knowing the temperature for cooking", "knowledge applied in real life", "like a lever", "calculating simple things like speed", "solving simple everyday problems".

For this network, these perceptions do not consider the association of Physics and Physics teaching with contemporary political aspects, and they prioritize the relationship between Physics and the individual

dimension of the students. Thus, although the undergraduates had only recently met, there was a common experience and conception regarding Physics teaching – which supports the possibility of studying this community as a network. A representation of the network formed by the class is shown in Figure 3.

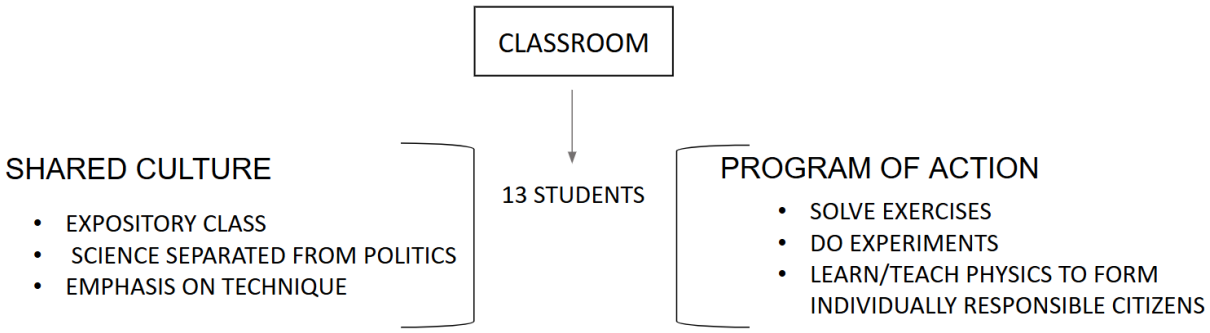

Figure 3 – Representation of the classroom network

As mentioned, the teacher presents an action program with the aim of discussing social and cosmopolitical aspects of science, therefore collective. Thus, there is a tension between the original action programs of each actor (the teacher and the students). The class does not have the same conception of science and the relationship between science and society as the teacher. In turn, the teacher represents values and action programs that the class did not expect. The encounter of these two actors and their action programs is a process of interference. A representation of this interference is shown in Figure 4. How the performances and action programs of all the actors involved will change throughout the process is what we narrate through our analyses.

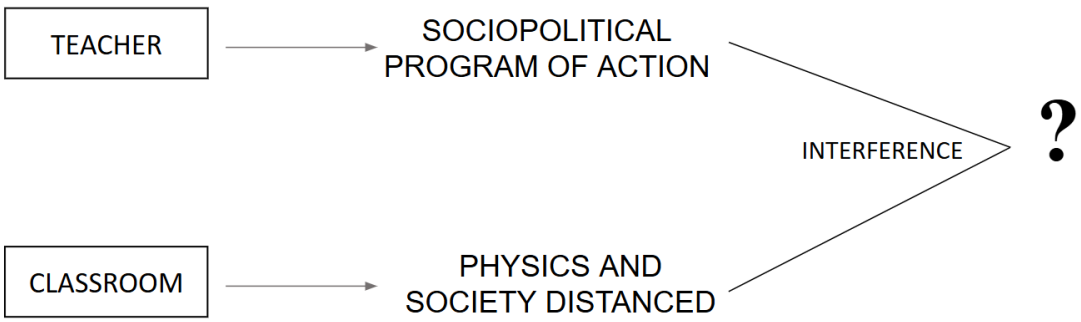

Figure 4 – Representation of interference.

A composition to measure the world

From the analysis of the class diaries, it was possible to identify that throughout the classes, in addition to interference, other types of mediation became evident in the context of the discipline. In the second meeting, for example, it is possible to highlight a composition-type mediation process when the students mobilized different types of tools (measuring tape, notebook, cell phone, pen, boards) to solve a problem (measuring the height of the building), through which they proposed an action plan that would not have been possible without the use of such tools. These relationships are represented in Figure 5.

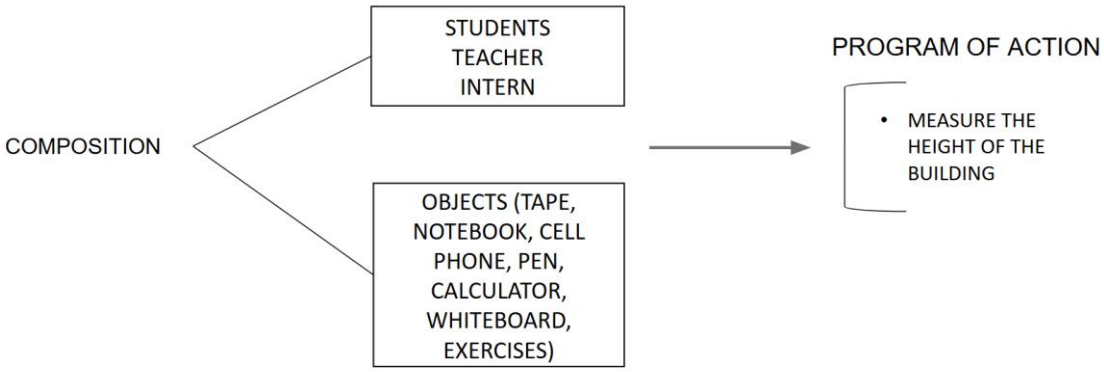

Figure 5 – Representation of the composition process.

Other forms of composition also occurred in subsequent classes – classes 3 and 4 – in which the class dedicated itself to solving exercises. In these situations, other objects played a role in the composition process: the calculator, to help with mathematical operations; the small whiteboards, which the groups used to sketch out their ideas, arrive at answers and socialize with the whole class; in addition to the exercise lists themselves, through which they mobilized mathematical and physical knowledge to solve problems. These mediations are also represented in figure 5.

Also in class 3, a new type of mediation was identified: the folding of space and time. By using a text that addressed the historical process of construction of scientific knowledge about the shape of the Earth, it can be said that the teacher opened a black box. The students had learned throughout their lives that the Earth was round, but they did not know how science had arrived at this knowledge. In bringing up these reflections, the teacher explained the actors involved, the experiments carried out (Eratosthenes' measurements), the controversies (the old flat-earth models), centuries of knowledge that were constructed and led to the round Earth model. This form of mediation, as well as the actors involved, are represented in Figure 6.

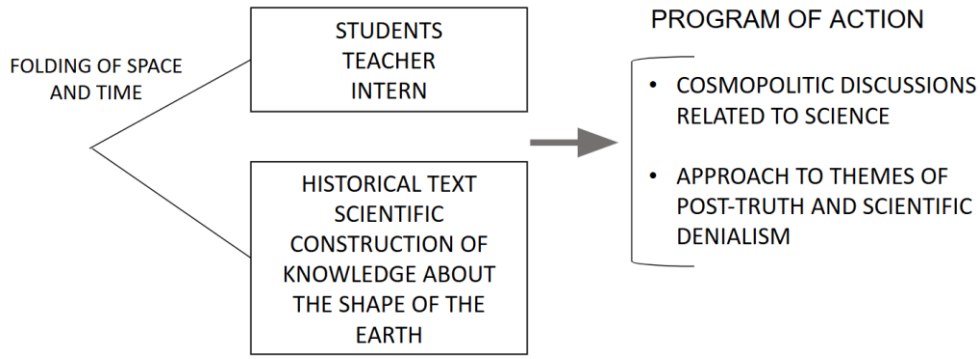

Figure 6 – Representation of folding of space and time process.

In this way, different actors were made explicit in a network that supports such knowledge, a network that was later closed again in a black box (round Earth model) when the students moved on to solving trigonometric calculation questions that, in turn, were based on the premise that the Earth is round.

A composition of discourses

Between classes 3 and 4, a new actor was mobilized and became part of the context of the discipline: a video. To investigate the role of this new actor as a mediator of the teaching-learning process, we sought to analyze a possible complexification of the networks mobilized by the students in their discourses on science and the flat-earther movement based on the analysis of the initial questionnaires and the homework. To do this, we mapped the different actants (human and non-human) mobilized by the students, because according to the theoretical perspective of Bruno Latour's Actor-Network Theory, the extension of a network – that is, the number of actants mobilized by it – is an indication of the stabilization of a proposition, so that the more actants are mobilized in a network, the more complex, stable and real it becomes (Latour, 2001).

The methodology used focused on Social Network Analysis, which, according to Venturini, Munk and Jacomy (2019), can be associated with Actor-Network Theory if we take into account some theoretical limitations between the two. The authors highlight, for example, that the existence of representational simplifications does not allow us to cover all types of mediations that can occur in a collective. Another limitation is associated with the mathematical equivalence of the network components, which makes it difficult to map different types of interactions in the same network. Furthermore, it is necessary to consider that the very definition of “nodes” and “networks” is different in the two theories, because, while in Actor-Network Theory each actant is in itself a network and each network is also an actant - with a reversibility of roles -, in mathematics, networks and nodes are essentially different, since they are calculated in different ways and defined by different properties.

Thus, when transferring this research methodology to the context of Science Education, it is important to consider that it will not be possible to understand all the nuances involved in the interactions between students and the actants they mobilize. And, even if some actants are more central to the network formed by the class, all actants will be equivalent for the same student - so that we will not be able to differentiate which actants are more important in each student's network. Finally, it is necessary to keep in mind that each node that makes up the network (i.e., each student and argument mobilized) is at the same time a network that mobilizes other actants. In Science Education, other studies have already used this methodology in the analysis of textbooks (Rosa, 2022) and educational legislation (Antunes Jr, Cavalcanti, & Ostermann, 2021), in mapping the literature in Science, Technology and Society (Böck, 2015) and in understanding students' knowledge networks (Teixeira, 2011).

In this study, Social Network Analysis was performed by mapping the arguments used by students in the initial questionnaire in contrast to the arguments used in the video task. Using the open source software Gephi 0.10.1, it was possible to develop four different networks, two related to the globe-Earth model and two related to flat-Earthism. In this graphical analysis model, the nodes represent the network's actants (whether human or non-human) and the edges represent the relationships between the different nodes. Based on the interactions between the nodes, a measure of the centrality of a given actant in the network is defined as degree, which represents the number of direct connections of each node that make up the network. Furthermore, the spatial arrangement of the nodes itself, which was given by the ForceAtlas2 visualization model, indicates which actants have more connections in common (resulting in an attraction and locating them close to each other) and which actants have fewer connections in common (resulting in a repulsion and distancing them from each other). Figures 7, 8, 9 and 10 show the results of the graphical analyses.

Figure 7 represents the first network formed by the students in relation to the Earth-globe model. It has 42 nodes, 13 students and 29 arguments, and 56 edges that relate the students to the mobilized actors. The network has as its central concept the node “limit of human perception”, which has degree 7 and indicates that the students justified the impossibility of perceiving the correct shape of the Earth to a limitation of the human being’s own perception due to the dimensions of the planet. Next, gravity, which has a degree of 6, was used to justify the round shape, as well as the photographs of the planet, with a degree of 5. Furthermore, the observation of how boats and “caravels disappear on the horizon” was used to justify the round-Earth model (degree 4) and several astronomical phenomena were also used, such as the phases of the moon (degree 3), day and night (degree 2), eclipses (degree 1), the apparent movement of the stars (degree 1) and the seasons (degree 1).

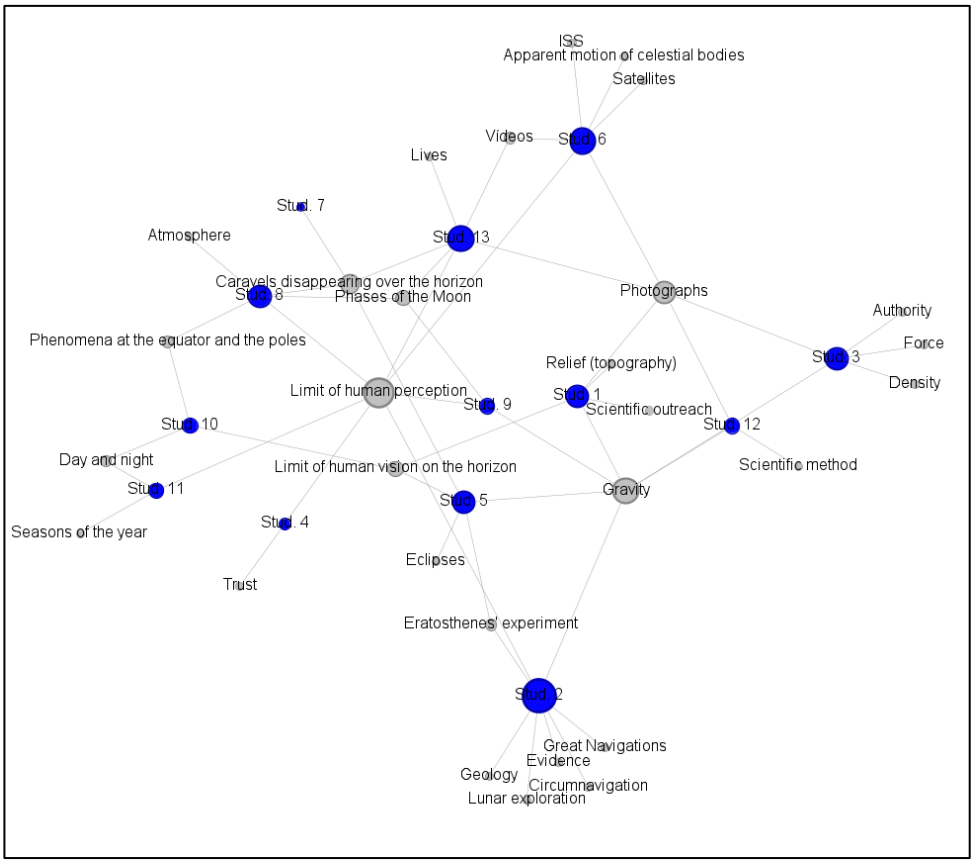

Figure 7 – Network of actors mobilized by the class in the initial questionnaire in discourses about science and associated with the Earth-globe model.

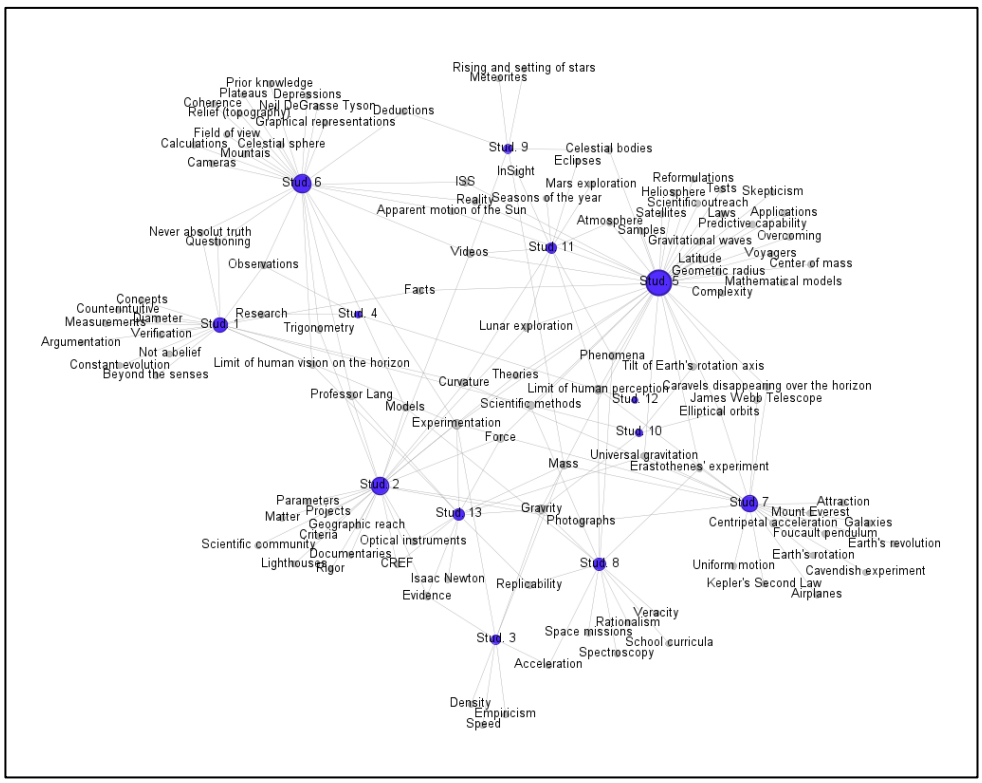

Figure 8 – Network of actors mobilized by the class after the video in discourses about science and associated with the Earth-globe model.

Figure 8, on the other hand, consists of the network of actants mobilized by the students in the homework, with regard to the Earth-Globe model, which has 135 nodes, divided between 13 Students and 122 concepts, and 185 edges that represent the mobilization of actants by the students. The central concept of this new network is “experimentation”, which has a level of 7, and is strongly associated by the students with the Earth-Globe model and the very concept of science. Gravity (level 6) and Limit of human perception (level 6) remained strong in their explanations, but new elements were mobilized: videos (level 5), curvature (level 4), scientific methods (level 4), observations (level 3), models (level 3), questions (level 2), trigonometry (level 2), research (level 2). Just as the degree represents the number of times an actant is mobilized, a student's degree represents the number of mobilizations he or she makes.

Thus, the comparison between the degrees of each student in the different networks can be an indication of how their discourses may have been complexified (or not) after the task. Table 2 consists of a comparison between the degrees of each student in relation to the Earth-globe model.

Chart 2 – Comparison of the number of connections made (degree) by each student in the initial questionnaire and in the analyzed task in relation to the Earth-globe model.

Student	Degree referring to the questionnaire	Degree referring to the task
1	5	18
2	8	23
3	5	8
4	2	3
5	5	39
6	6	25
7	1	21
8	5	13
9	3	6
10	3	4
11	3	10
12	3	1
13	6	12

Source: the autors.

To evaluate if there is a statistically significant difference between the two cases - that is, between the number of actants mobilized by the students in relation to the Earth-globe model in the initial questionnaire and the number of actants mobilized by the students after the video - we performed the Wilcoxon test (suitable for non-parametric distributions), which returned $p = 0.0033$, which indicates that there is a statistically significant difference at the 1% level.

Figure 9, in turn, consists of the first network formed by the class in relation to the flat-earther movement and had 42 nodes, 13 of which were students, 29 arguments, and 58 edges. At first, the flat-earther movement was strongly associated with conspiracy theories, with the actant “conspiracy theory” being the central concept of the network, with a level of 7. The students also related the flat-earther movement to the perception of the “straight horizon” (level 6), the lack of knowledge, represented by the actant “ignorance” (level 5), misinformation (level 5) and an empiricist conception of the world, represented by the actant “empiricism” (level 4).

While Figure 10 consists of the network of actants mobilized by the class in relation to the flat-earther movement after the video task. This network had 42 nodes, 13 of which were students, 29 arguments and 57 edges. After the video mediation, new actants began to be mobilized, such as scientific denialism (level 7) and the influence of religion (level 6) and political and ideological factors. This change in the central aspects of the network may represent a change in the perception of students, who now realize that the flat-earther movement is not just a lack of access to information or knowledge, but a denial of science itself.

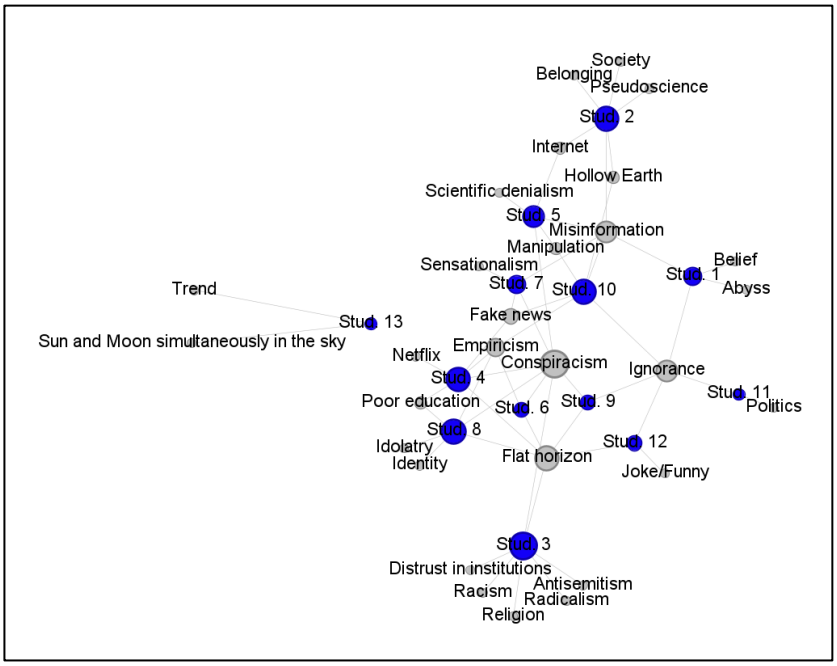

Figure 9 – Network of actors mobilized by the class in the initial questionnaire in discourses about the flat-earther movement.

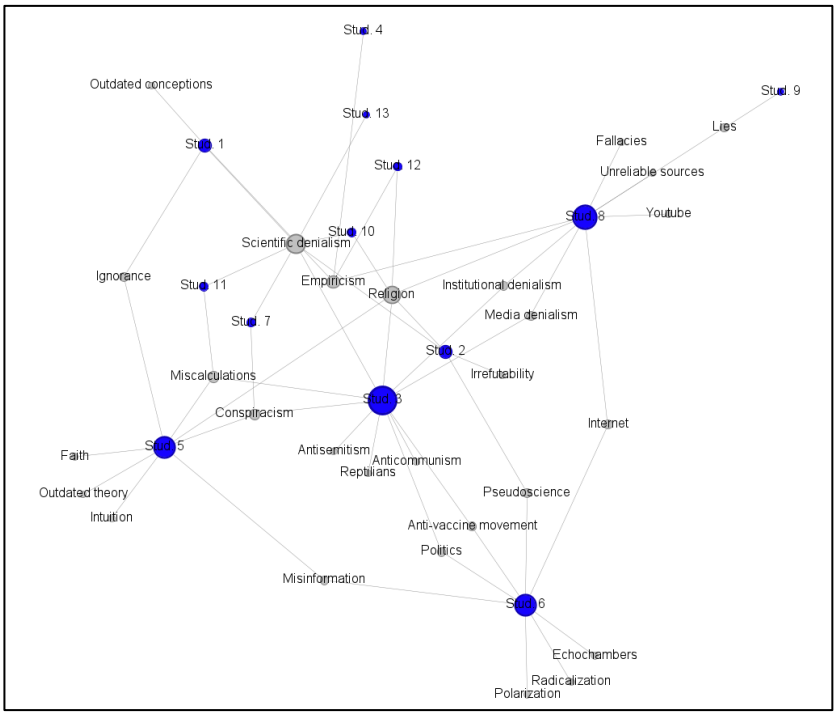

Figure 10 – Network of actors mobilized by the class after the video in discourses about the flat-earther movement.

In the same way that we compared each student's grades for the Earth-globe model, in Table 3 we provide a comparison between each student's grades in relation to flat-earthism.

Chart 3 – Comparison of the number of connections made (degree) by each student in the initial questionnaire and in the task analyzed in relation to flat-earthism.

Student	Degree referring to the questionnaire	Degree referring to the task
1	4	5
2	6	4
3	7	11
4	6	1
5	5	8
6	3	8
7	4	2
8	6	9
9	3	1
10	6	2
11	2	2
12	3	2
13	2	5

Source: the autors.

We also performed the Wilcoxon test for this case, which returned no statistically significant difference between the two data sets. Thus, we can state that there was a complexification of the students' discourses in relation to the globe-Earth model (since there was a statistically significant difference), but there was no complexification in relation to the flat-Earth model. As an object of future studies, we can evaluate why the students expanded their conceptions regarding one model, but not regarding the other. Without an in-depth study, we are not able to state with certainty what occurred, but we can raise some hypotheses. Perhaps the globe-Earth model is more consistent and, therefore, made more sense to the students, allowing them to mobilize more arguments. Another possible explanation would be associated with how seriously the students were able to take the flat-Earth model, since, already knowing that this model is not consistent with the scientific explanation, the students may not have paid as much attention or given as much importance to the arguments associated with flat-Earthism. Therefore, in future studies we should also be more careful when problematizing subjects in which the scientific positioning already seems obvious, as this may influence students to not pay much attention to the so-called non-scientific positioning.

In terms of mediation, it is possible to identify the occurrence of the students' composition process with the video, since they now began to mobilize arguments that, in isolation, were not made explicit, but which became present with the mediation of the video.

However, as can be seen in Figures 7 and 8, the actors mobilized by the students in the discourses on science are restricted to human and non-human actors of a scientific or epistemic dimension – since scientific concepts (mass, gravity, force, etc.), scientists (such as Professor Fernando Lang) and elements

such as theories, phenomena, models, etc. are mobilized. Some exemplary excerpts referring to the video task are highlighted below.

> *Student 1: "[...] for the scientist to conceive [globe-earth], it was first necessary to know several other concepts, to arrive at a diameter measurement, to prove that the Earth has curvature, that is, it is not something very intuitive."*
>
> *Student 2: "in order to be carried out, science needs parameters, criteria, evidence and experiments for a theory to be accepted. Not just any guess can be accepted as science, which is why flat-earthism cannot be accepted as a scientific model."*
>
> *Student 2: "paraphrasing Professor Lang again: "If the Earth were flat, there would be no point in building lighthouses on towers tens or hundreds of meters above sea level. A tower high enough to be above the level of rough seas (that is, just a few meters) would be enough."*
>
> *Student 8: "The scientific method has proven useful several times in practice, and not just in theory. For example, space missions on a heliocentric globe model." Student 7: We have this information [that all bodies governed by gravity tend to have a spherical shape] from the law of universal gravitation, which says that all bodies that have mass are attracted to each other, and, together with Kepler's 2nd law, we have that the planets only describe circular orbits around the Sun if they are subject to a uniform motion together with a centripetal acceleration.*

On the other hand, when we look at Figures 9 and 10, that is, at the actors mobilized in the discourse on the flat-earther movement, it is possible to identify the predominance of actors of a social dimension – including religion and politics, for example, as in the excerpts from Task 2 highlighted below.

> *Student 7: Most flat-earthers defend an empirical view of the world, and refuse to look at evidence that is right in front of them because it contradicts many of the things they believe in, such as creationism.*
>
> *Student 4: [flat-earther arguments are based on] guesswork, deductions, and simple (quick) observations without studies.*
>
> *Student 3: "the vast majority of people who believe in a conspiracy theory and anti-science are more likely to interact with people with such interests, in addition to having less trust in academic sources, media sources, and government entities. In addition, many of these scientific beliefs end up intertwining with political beliefs (as can be seen with the anti-vaccine movements) and with religious beliefs (such as the debate about the Big Bang and the theory of evolution seen in the video). Because of this, many times a debate that is expected to be scientific can actually result in a debate fought along political and religious lines. "They are not flat-earthers because they believe the Earth is flat, they are flat-earthers because if the Earth is flat, it will validate their other beliefs" – Dan Olson, documentary 'In Search Of A Flat Earth' When you are going to debate with someone about the idea that the Earth is flat, don't expect it to end there. Be prepared to talk about vaccines, reptilians, Jews and communism. For many, attacking the flat Earth is like attacking their holy book, their religion or their culture, but it is important to remind them that being religious does not mean being against science.*
>
> *Student 12: They dispute the theory of evolution "how did man come from monkeys?" - It has a very strong religious influence.*
>
> *Student 5: "[...] here religion starts to mix with science. Bringing theological concepts into a scientific debate in itself invalidates the argument, since religious concepts are based on faith and not on the scientific method."*

These performances indicate that this video, in particular, did not contribute to broadening students' understanding of the social dimension of scientific knowledge. On the contrary, the results seem to point to a reaffirmation of the dichotomy between science and society, since social aspects were attributed to the flat-earther movement, but not to science.

This result, although not expected or intended by the research group and the teacher, is consistent with the performances associated with the composition process. The video proved to be a tool that allowed

most students to complexify their discourses in relation to science and the Earth-globe model, causing students to mobilize a greater number of actors after the video performance. However, the composition did not lead to a mobilization of actors from the social dimension by students when addressing science, as expected by the teacher and researchers. The video was also not enough to significantly broaden students' conception of flat-earthers, although it favored an understanding of aspects that had not been explored before. In this sense, there was interference between the students' and the teacher's action program. The result was a new action program that did not fully correspond to what the students had previously expected or what the teacher had proposed. In other words, the students demonstrated changes in the way they mobilized actors on the topic, but they did not fully correspond to the pedagogical objectives expected by the teacher.

The analysis also made it possible to identify that some students brought elements that were not present in their initial responses (questionnaires) and that were not actually present in the video. For some students in particular, the results once again exceeded the performance expectations expected by composition-type mediations and came closer to interference-type mediation – since the discourses formed by the meeting of two actors have a performance that was not foreseen in the initial action programs – and can be seen in the excerpts from Task 2 highlighted below.

> *Student 5: "Modern mathematical models still consider different characteristics of the Earth's shape. According to Cruz (2018), from the UFRJ Institute of Geosciences, "Through measurements taken at different latitudes, significant differences were identified between the planet's geometric radii." What can be concluded from this is that even the regular spherical model has been outdated since the 17th century. Measuring the Earth's shape accurately is extremely complicated and not at all trivial."*
>
> *Student 7: How could we, such small beings in such an immense universe, be able to say something with such certainty? For example, a few months ago, the James Webb telescope took photos of galaxies that are further away than current models allow. This does not mean that our entire conception was wrong, just that we do not have a concrete image of everything. But of course, there are several arguments that prove that the flat Earth theory is wrong, since it is something accessible and close to us, such as Eratosthenes' experiment.*

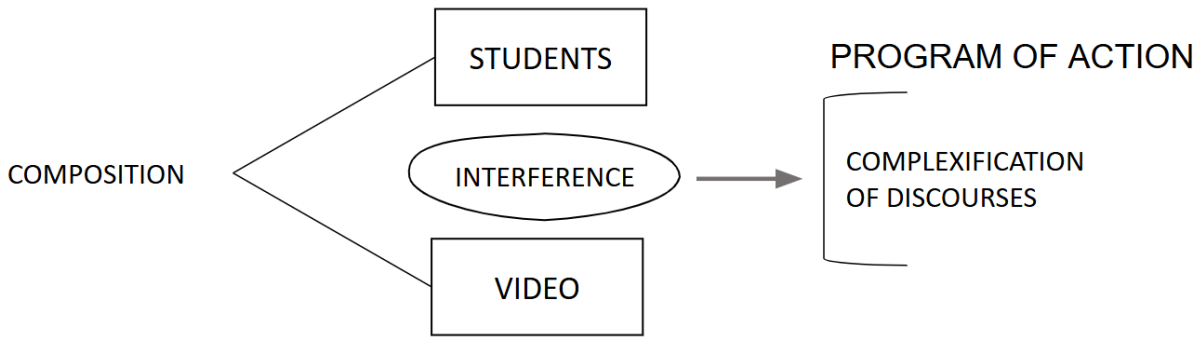

Figure 11 – Representation of composition and interference processes.

In general, it was also possible to identify in the debate held after the video task, which took place in class 5 – the transcript of which is available at Annex 2[11] – the mobilization of arguments that came from the video shown and from discussions in class, so that the students' discursive performance was configured based on the composition with the video watched.

The emergence of a new actor: class-teacher

As identified from the questionnaires of the first class, all students had a shared experience of Physics, mostly traditional and separated from social issues. The researchers expected to identify variations in the

[11] Annexes published in Harvard Dataverse: https://doi.org/10.7910/DVN/KZET41

discourses regarding the proposed experience. However, when faced with an initial question from the professor in the final discussion, no student raised political or social issues, or the issue of misinformation in their responses. The students reinforced the traditional teaching they had received, and when talking about what the role of teaching would be, they only reinforced epistemic (and not political) aspects, such as the importance of arousing students' curiosity and engaging them in experimental practices. Therefore, the activities carried out seem to have generated insignificant changes in the students' discursive performances. The professor then began to challenge these perceptions, returning to the initial action program of the discipline, as indicated in Event 1 shown in Chart 4.

Chart 4 – Interactions of Event1.

Turn	Speaker	Speak
1	Teacher	Everyone is harping on about how important it is, in the end, for people to know science or be curious about science. But why would that be important for society in general? Just to close the argument like this... why do we value... because it could be like this, right? I like science, but not everyone is obliged to like science. There are people who like anything and I don't. Why would it be important for everyone who leaves school to like and understand a little bit about science? What could be taken from this discussion that we had to this larger scope, for example?
2	Student 2	I believe that what makes science advance would be, for example, the creation of laws to encourage science, or encourage education, funding for people to be able to work with science. When you have people who pay taxes and know science, who value science, they demand greater investment in science from the government. And if a society has knowledge of science, the government is a reflection of that society and will have this consensus that investment in science is necessary for us to evolve as a society. For us to discover, I don't know... how to stop global warming, it will be through investment and this investment will be given by people who are aware that science is important and I think that in the end this is the cycle.
3	Student 1	I think that, complementing what you said, it is solving society's own problems, right? Because, whether you like it or not, you will have people there who will have all the scientific basis to find various problems and end up, through these investments, solving them.
4	Student 2	If we don't have a leader who values science, we can't have funding and work with science. And we can put leaders who know science, making more people have knowledge of science and vote for people who know they will invest in science. For example, investing in education, and education is the basis for science.
5	Teacher	Okay, and one last question just to wrap things up: would greater investment in science necessarily lead to a better society? Or could it be that more science could even reinforce more social inequalities?
6	Student 1	It depends on where you point this science. Because if you give all this knowledge to elite people, for example.
7	Student 6	Like artificial intelligence. Which, like, artificial intelligence isn't helping anyone. It's just taking people's jobs, you know?
8	Teacher	So, we are pointing out that science is important, right? But what precautions would need to be taken within what you are proposing? In addition to investment in science, what would be necessary in this social model that you are proposing?
9	Student 3	It has to reach everyone, that's the biggest challenge. It's about reaching everyone from all social classes, so that everyone has the same level of knowledge, the same desire to change, the same... you know? I'm not saying the same worldview, but the same... but everyone has access. I think

Turn	Speaker	Speak
		that's the hardest part, so that it can only be developed in a more balanced way.
10	Student 1	I have a good example on this issue, because in my opinion it is a very difficult issue to balance, let's say, whether more science means a good thing or a bad thing. There was a physicist during the First World War who was the first to isolate hydrogen, if I'm not mistaken... and... nitrogen, sorry. And this component was very important for you to be able to use it as fertilizer. So, during the First World War, Germany had large factories to isolate nitrogen for agribusiness, so to speak. But this physicist, because he was also a patriotic view of his country, decided to use this knowledge, these advances, for example, to increase Germany's weapons capacity during the First World War. So he used this same knowledge of isolating nitrogen to make weapons. Later, he was one of those who managed to develop mustard gas, for example. Although, for example, he was a Nobel Prize winner, he was not known by the academic community because of the use of this knowledge. So even today, for example, we have an influence on our agriculture, for example, due to points of his discovery, but this knowledge, just like the knowledge of the atomic bomb itself, has to be used with great care.
11	Student 4	I think that the Second World War also exemplifies very well that in the concentration camps they were doing science in a certain way, but what happened, happened.
12	Student 1	Yeah, the medical experiments.

Source: the autors.

Following the teacher's questions (Turn 1), the students began to explain notions about the political dimension of science (Turns 2 to 4). It is interesting to note that they began to address what Latour calls public opinion and the importance of it being favorable to there being investment in science. It should be noted that this argument had never been brought up by the teacher during the discussions nor had it ever appeared among the students themselves before.

In view of this social dimension brought up by the students, a possible conception is noted that science would always be connected to a positive evolution of society. In view of this, the teacher asked a new question (Turn 5). From this moment on, some students began to bring up the importance of thinking about social justice together with science, again a discussion that was not presented by the teacher and that had not yet appeared among the students (Turns 6 and 7). The teacher, once again, deepened the tensions brought up by the class (Turn 8). In response, the students began to argue and provide examples of the political dimension of science that went beyond the original discussions presented by the teacher: issues of social class (Turn 9), military science (Turns 10 and 11) and medical experiments (Turn 12).

After a series of rounds of provocations, through questions, the class began to reflect on social justice and the political commitment of science, evoking examples that were not present in their original discourses. This is therefore a case of interference in which the performances presented by the mediation of the teacher and the class exceed the original isolated performances (figure 12).

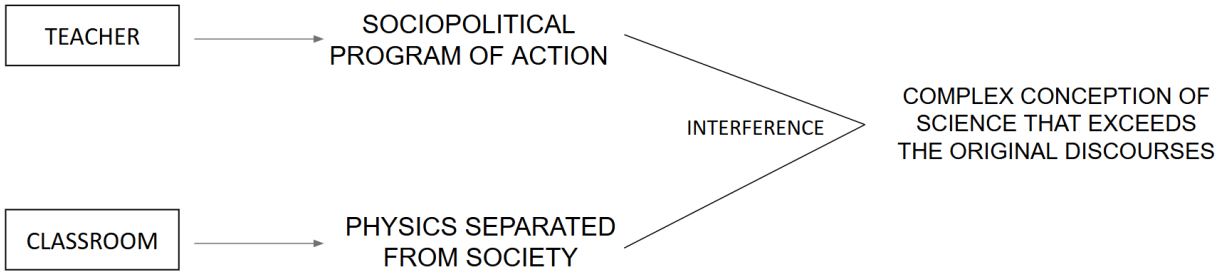

Figure 12 – Representation of the final interference process between teacher and classroom.

The students had a repertoire on the political dimension of science that was not mobilized spontaneously. This repertoire was independent of the discussion of the subject itself. On the other hand, in the face of dialogue with the teacher, these repertoires began to be mobilized. It should be emphasized that the mediating technology was the question. At no time did the teacher present the answer during the discussion, or reprimand the students. On the contrary, each new statement was used as a starting point for a new question in order to make explicit the tensions between the different conceptions. Thus, through this mediation process, through the question, it was possible to obtain a discursive performance by the teacher-class collective that brought reflections on social justice and political aspects that were not found in isolated performances.

FINAL REMARKS: THE EARTH IS STILL ROUND

In this paper, we present an empirical study of a group formed by a teacher-researcher and a class in a teaching unit that addressed the topic of post-truth and, more specifically, flat-eartherism. After collecting the data, we decided to interpret the records in light of Bruno Latour's concept of mediation. Our goal was to understand how these mediation processes occurred throughout the classes analyzed and how they contributed to the variation in the performances and agencies of the subjects involved. To this end, we sought answers to two research questions, which we have compiled below.

(i) throughout the process, what are the mediation mechanisms – in the sense attributed by Latour (2001) – that occur in the classroom collective?

As might be expected, throughout the teaching process, the four types of mediation appeared. First, the teacher's performance involved a delegation of the research group and institutional interests. Furthermore, the meeting between the professor-researcher and the class involved interference, since the original action plans began to be stretched towards something new, which would only be recognized at the end of the process. The teaching unit itself opened a black box (the shape of the Earth), indicating that this proposition is supported by theories, experiments, hypotheses and tools articulated over centuries in different regions of the globe, which highlighted the folding of space and time.

Throughout the classes, the students needed to mobilize material and symbolic instruments - calculators, rulers, equations and theories - to draw conclusions about reality, inferring everything from the height of a building to the radius of the Earth. This compositional mediation indicated that the subjects' performance was enriched by the mastery of instruments, which is in line with the socio-interactionist discussions proposed by authors such as Wertsch (1985; 1991). This approach is not unexpected, since the Vygotskian perspective can be understood as consistent with a relational metaphysics (Stetsenko, 2008).

While Vygotskian-oriented studies emphasize the expansion of higher mental functions through the mastery of instruments (e.g. memory, ability to do calculations, etc.), in our work, we perceived the extension of the potential of compositional mediation for carrying out complex tasks such as positioning in relation to the epistemic and political interrelations of a given problem (in this case, flat-earthism). The students produced richer discourses, crossing different dimensions about the theme throughout the teaching unit.

The use of questions by the teacher, a symbolic instrument mobilized in the unit's debate, provided an encounter between the teacher and the students, which generated a new process of interference, in which the

conception of science gained complexity and breadth, going beyond the concepts that had been presented by the teacher in the classroom.

(ii) How do the different types of mediation alter the discursive performances of students and teachers about the role of teaching physics/science in basic education?

Among the four forms of mediation, there is a preponderance of mediation by composition and interference in the sense of altering the performances of the members of the collective. The adoption of material and symbolic instruments allowed students to enter into the discussion about the radius and shape of the Earth, which would not have been possible, or at least would have been much weaker, without the mastery of these semiotic instruments. The same happened with the use of a video that presented arguments about flat-earthism. From it, students were able to mobilize richer and more complex discourses. On the other hand, without the immediate presence of the video and the teacher's discussions, students recovered original discourses. That is, encountering different materials and discourses in a specific way is not enough to promote a lasting change in performance.

The most surprising result is the articulation of political and epistemic arguments in the students' discourses, which were not present in their original discourses and were not explicitly presented by the teacher or in the materials used, after a series of questions asked by the teacher. That is, when the teacher adopted a questioning position in order to intensify the debate, the students produced more sophisticated discourses with more elements than the original set of arguments, both from the class and the teacher. Thus, we indicate an effective process of interference, in which the final performance was not the sum of the original performances. We emphasize that these are not reflections that the students made after the class and improved their performances. The existence of the question led to changes in the student's performance, causing him to mobilize arguments not articulated before and that were not brought up by the teacher. Thus, the question expanded opportunities for epistemic-political reflexivity of the teacher-class collective.

We identified a parallel between what we found in the classroom and the discussion made by Wertsch (1991) and Pereira et al. (2009). The question is an important element capable of modifying the forms of action of the new teacher-class actor. The child alone did not remember where the toy was and the parent did not know, but after the question the memory came to exist (Wertsch, 1991), and the “more capable” partner responded better after the questioning of the “less capable” partner (Pereira et al., 2009). Similarly, the new performances presented by the class were only possible after the teacher’s questions. More than that, the discourses presented by the students were not the teacher’s discourse, so they went beyond the original proposal.

In the literature of the area of Science Education, there is a wide production on the role of the question in learning, especially studies that explore discursive interactions in the classroom and argumentation. This study corroborates the knowledge that the field has been building in this direction, regarding the relevance of a questioning stance by teachers in their interactions in the classroom (Santana & Sedano, 2023), with questions situated in the social plane of the class, favoring collective constructions (Chin, 2007), and understood as a dialogical instrument with specific didactic purposes (Machado & Sasseron, 2012). Despite the similarities with such studies, we did not find research that emphasizes the role of questions or interactions in the context of themes related to post-truth in teacher training.

Therefore, our research adds to the indications of the field, as it analyzes situations in which students were faced with a socioscientific theme in the context of denialism, in which epistemic and political arguments were mobilized. The question, then, is understood as an element that promotes the modification of the original performances for the teacher-class actor in classes focused on discussing the post-truth context, since more complex and previously unpresented arguments were mobilized than if the questions had not been asked. In this sense, our study dialogues with the research by Kelles (2023), developed in the context of Basic Education. The study presents analyses of interactions in which high school students discuss topics such as global warming and vaccines, which brings it closer to our research. Its results highlight the role of the teacher's questions in discussions with the class, which sought to: challenge arguments of authority, direct students' reflection towards an analysis of what was conveyed by conspiracy theories or misinformation, in addition to stimulating practices of argument evaluation.

In our study, although we did not categorize the intentionality of the teacher's questions, we observed relevant similarities with the results of Kelles (2023). In both cases, the teacher's questions promoted similar consequences among students, in discussions about post-truth themes: student positions that made explicit

the political dimension of science, as well as a more complex perception of science, capable of going beyond the scientific enterprise as synonymous with social evolution.

Thus, we reiterate the potential of the dialogic class. If the teacher had prioritized, in his class, the action of stating what his view on the subject was, at most, the students would have come closer to the teacher's view. Through questioning, as a mediational resource, on the other hand, the discourses mobilized went beyond the discussions presented by the teacher. The data presented here indicate that the notion that reflective teaching, based on constructive questioning, is a powerful way to develop knowledge and positioning about the world, which is in line with the notion defended by Freire (2014) in his proposal for a pedagogy of questioning.

Another important aspect of research in the field of Science Education is the role of the teacher in the pedagogical processes. First, it was important for the teacher to structure the unit in order to engage the class throughout the process. More than that, it was necessary for the teacher to be involved at all times, bringing the debate back to the field of interest, in order to ensure that the students could advance in their understanding and deepen their discourse. This conclusion is important because it goes against discourses that circulate in the educational environment, tending to place the teacher as a supporting actor in the pedagogical process. Students do need to work actively in the classroom, but the teacher also plays a leading role in the sense that he or she supports the work around the proposed activities. In this sense, our data corroborate the defense of the teacher as a critical intellectual (Contreras 2012; Souza, Rezende, & Ostermann, 2016), builder of knowledge.

Furthermore, it is important to emphasize that the results of such pedagogical processes cannot be expected to be linear and progressive throughout the students' trajectory. As shown by our data, the teacher had to constantly instigate reflections on the part of the students. In classroom practice, what will be mobilized by the class does not depend solely on the teacher's objectives or even solely on the instruments he or she uses. The role of different non-human actors in this process was evident - video, historical text, discussions, questions, calculators, practices, calculations - making it clear to the teachers in training that each strategy assumes different roles in mobilizing the class and that the expected results will not always correspond to what the teacher aims for. In our case, the video was not able to mobilize the students in all the aspects intended by the teacher, just as other elements that are commonplace in a classroom, such as the use of a whiteboard, text or calculator, demonstrated relevant roles in the mediation that occurred in the classroom. Thus, these data provide teachers in training with information that can help them reflect on the different elements they can use in the classroom and on their different roles in different contexts and themes, considering the complexity of the mediations discussed here.

The transposition of Bruno Latour's Studies of Science to the context of Science Education is widely used and discussed as a theoretical-methodological framework in the literature in the area (Queiroz, 2010; Coutinho, Goulart, Munford, & Ribeiro, 2014; Coutinho, Lobo, Freitas, Viana, & von Linsingen, 2022; Lima, Ostermann, & Cavalcanti, 2018; Lima et al, 2019; Silva, Calefi, & Coutinho, 2018), including to address the discussion of socio-scientific issues in the classroom (Gois, Lima, & Moraes, 2024). In the context of the present study, thinking about educational processes from the lens of Latour's mediations allowed us to identify how the different mediations involving human and non-human actors were able to promote changes in the performances of the class and class-teacher collectives. In this way, it was possible to differentiate the roles assumed by humans and non-humans (such as videos, texts and measuring instruments) in the educational process and, above all, to identify the role of the question as an important element in changing performances, which corroborates the idea that questioning can increase the agency of subjects (and not only the presentation of content). Although this was identified in discussions on learning concepts (Pereira et al., 2009), the present study makes it clear that it is also relevant in a socio-scientific proposal. However, when evaluating educational practice based on mediation processes, it was necessary to renounce specific and individual aspects of each student in exchange for attitudes and perceptions shared among the class. This process of homogenization allows the class to be characterized as a collective, but erases individual characteristics that can be crucial in the teaching-learning process. Thus, there is a tension between seeking generality or gaining specificity in any empirical study, and it is up to researchers to make a subjective choice about the granularity of the investigation (i.e., how much specificity they are willing to give up in order to obtain greater generality in the data).

Based on the results, we can indicate some considerations about teacher training in the context of post-truth. First, scientific concepts and semiotic instruments typical of formal education seem to cause an increase in complexity in the subjects' discourses on the proposed theme and, therefore, enhance their

autonomy on the topics addressed. Future research should be carried out to determine whether learning formal concepts impacts decision-making on sociopolitical issues.

In principle, considering the complexity of discourses after formal learning, there are indications that scientific training should intensify its concerns with the teaching and learning of concepts. This does not mean adopting a technical and content-based perspective. The scientific dimension does not exhaust contemporary problems, which are of a socioscientific nature. On the other hand, without a minimum understanding of the concepts and semiotic instruments that circulate in this context, it is very difficult to be part of the public debate. Thus, we agree with an increase in the politicization of scientific education (Moura, 2021) without losing sight of a concern with the mastery of instruments that, in fact, increase the social participation of the subjects involved.

Thus, our results lead us to understand science teacher training in the post-truth era as a dialogical process that depends on the approach of scientific concepts and semiotic instruments, while also tensioning the social and political debate about science. In this process, the teacher-trainer occupies the place of a critical intellectual, who produces knowledge, tensions discussions and defends the question as a pedagogical principle, capable of enhancing teacher training.

Finally, we understand that the analysis of mediation processes and changes in performance that occur from the articulations between different actors can be fruitful for the interpretation of didactic situations. To this end, new studies (empirical and theoretical) that deepen the dialogue between Latour's proposal and Vygotskian mediation theory can be an important avenue of investigation. Furthermore, the analysis proposed in this article can be expanded to other classroom situations, other levels of schooling and teaching approaches, such as that found in Queiroz (2010). This theoretical proposition may be important in the sense of contributing to the approximation of teaching and learning theories with contemporary discussions of sociology of science.

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REFERENCES

Allchin, D. (2023). Ten Competencies for the Science Misinformation Crisis. *Science Education, 107*(2), 26, 74. https://doi.org/10.1002/sce.21746

Allchin, D., Andersen, H.M, & Nielsen, K. (2014). Complementary Approaches to Teaching Nature of Science: Integrating Student Inquiry, Historical Cases, and Contemporary Cases in Classroom Practice. *Science Education, 98*(3), 461–86. https://doi.org/10.1002/sce.21111

Antunes Jr, E., Cavalcanti, C. J. H., & Ostermann, F. (2021). A Base Nacional Comum Curricular como revocalizadora de vozes dos Parâmetros Curriculares Nacionais: o currículo Ciência, Tecnologia e Sociedade na educação científica para os anos finais do Ensino Fundamental. *Caderno Brasileiro de Ensino de Física, 38*(2), 1339-1363. https://doi.org/10.5007/2175-7941.2021.e75579

Bakhtin, M. (1981). *The Dialogic Imagination: For Essays by M. M. Bakhtin*. Michael Holquist (Ed.). United States of America, Austin: University of Texas Press.

Böck, B. S. (2015). *Ciência, tecnologia e sociedade e a construção social da tecnologia no Brasil: Uma representação por análise de redes sociais* (Dissertação de mestrado). Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, Rio de Janeiro, RJ. Recuperado de http://pppro.cefet-rj.br/T/362_Bruno%20Stefoni%20B%C3%B6ck.pdf

Bondezan, G., & Kawamura, M. (2022). Possibilidades e entraves para o diálogo com o terraplanismo no ensino de ciências. *Experiências em Ensino de Ciências*, *17*(1), 76-92. Recuperado de https://fisica.ufmt.br/eenciojs/index.php/eenci/article/view/1085

Callon, M. (1984). Some elements of a sociology of translation: domestication of the scallops and the

fishermen of St Brieuc Bay. *The sociological review, 32*(1_suppl), 196-233.

Chin, C. (2007), Teacher questioning in science classrooms: Approaches that stimulate productive thinking. *J. Res. Sci. Teach.,* (44), 815-843. https://doi.org/10.1002/tea.20171

Contreras, J. (2012). *A Autonomia de Professores*. São Paulo, SP: Cortez.

Coutinho, F. Â., Goulart, M. I. M., Munford, D., & Ribeiro, N. A. (2014). Seguindo uma lupa em uma aula de Ciências para a Educação Infantil. *Investigações em Ensino De Ciências*, *19*(2), 381–402. Recuperado de https://ienci.if.ufrgs.br/index.php/ienci/article/view/85

Coutinho, F. Â., Lobo, S. I. S., Freitas, A. P. S., Viana, B. M. M., & von Linsingen, I. (2022). Contribuições para a Compreensão da Natureza da Ciência na Educação em Ciências: um Estudo a Partir da Concepção Latouriana Sobre a Fabricação da Objetividade Científica. *Revista Brasileira de Pesquisa em Educação em Ciências*, e35690, 1–24. https://doi.org/10.28976/1984-2686rbpec2022u817840

Frank, C. (1999). *Ethnographic Eyes: A Teacher's Guide To Classroom Observation*. Portsmounth, United States of America: Heinemann

Freire, Paulo. (2013). *Pedagogia Da Esperança: Um Reencontro Com a Pedagogia Do Oprimido*. Rio de Janeiro, RJ: Paz e Terra.

Freire, Paulo (2014). *Por uma pedagogia da pergunta*. Rio de Janeiro, RJ: Paz e Terra.

Gois, E., Lima, N. W., & Moraes, A. G. (2024). Não Tem Saída Fácil: Tensão entre Autonomia Epistêmica e confiança na Ciência como caminho para a Educação em Ciências Contemporânea. *Revista Brasileira de Pesquisa em Educação em Ciências*, *24*, e49070-64, 1-64. https://doi.org/10.28976/1984-2686rbpec2024u427490

Green, J., & Bloome, D. (1997). Ethnography and Ethnographers of and in Education: A Situated Perspective. In: *Handbook Of Research On Teaching Literacy Through The Communicative And Visual Arts* (pp 181–202). Cambridge, United Kingdom: Cambridge University Press.

Heidemann, L. A., Moraes, K., & Giongo, S. L. (2020). Evadir ou persistir? Uma disciplina introdutória centrada no fomento à persistência nos cursos de licenciatura em Física. *Revista Brasileira de Ensino de Ciências e Matemática, 3*(1), 160-188. https://doi.org/10.5335/rbecm.v3i1.10091

Hilger, T. R., & Mariniak, M. R. (2022). Terraplanismo como temática na formação inicial de professores no contexto do PIBID. *Experiências em Ensino de Ciências*, *17*(3), 18-33. Recuperado de https://fisica.ufmt.br/eenciojs/index.php/eenci/article/view/1119

Jasanoff, S. & Simmet, H. R. (2017). No Funeral Bells: Public Reason in a 'Post-Truth' Age. *Social Studies of Science*, *47*(5), 751–70. https://doi.org/10.1177/0306312717731936

Kelles, L. F (2023). *Informação, mídia e ciência em aulas de Biologia: uma análise de eventos de letramento em uma turma do 1° ano do Ensino Médio*. (Dissertação de Mestrado). Programa de Pós-graduação em Educação: Conhecimento e Inclusão Social. Faculdade de Educação, Universidade Federal de Minas Gerais, Belo Horizonte, MG. Recuperado de http://hdl.handle.net/1843/59688

Latour, B. (2001). *A Esperança de Pandora*. Bauru, SP: EDUSC.

Latour, B. (2004). "Whose Cosmos, Which Cosmopolitics?". *Common Knowledge, 10*(3), 450–62. Recuperado de https://muse.jhu.edu/pub/4/article/171401

Latour, B. (2005). *Reassembling the Social: An Introduction to Actor Network Theory*. Oxford, England: Oxford University Press.

Latour, B. (2020). *Onde Aterrar? Como Se Orientar Politicamente No Antropoceno?* Rio de Janeiro, RJ: Bazar do Tempo.

Lima, N. W., Vazata, P. A. V., Moraes, A. G., Ostermann, F. & Cavalcanti, C. J. H. (2019). Educação em Ciências nos tempos de Pós-Verdade: Reflexões metafísicas a partir dos Estudos das Ciências de Bruno Latour. *Revista Brasileira de Pesquisa em Educação em Ciências, 19*, 155-169. https://doi.org/10.28976/1984-2686rbpec2019u155189

Lima, N. W., Ostermann, F., & Cavalcanti, C. J. de H. (2018). A não-modernidade de Bruno Latour e suas implicações para a Educação em Ciências. Caderno Brasileiro de Ensino de Física, *35*(2), 367–388. https://doi.org/10.5007/2175-7941.2018v35n2p367

Machado, V. F., & Sasseron, L. H. (2012). As perguntas em aulas investigativas de Ciências: A construção teórica de categorias. *Revista Brasileira de Pesquisa e Educação em Ciências*, *12*(2), 29-45. Recuperado de https://periodicos.ufmg.br/index.php/rbpec/article/view/4229

Martins, A. F. (2020). Terraplanismo, Ludwik Fleck e o mito de Prometeu. *Caderno Brasileiro de Ensino de Física*, *37*(3), 1193-1216. https://doi.org/10.5007/2175-7941.2020v37n3p1193

Marineli, F. (2020). O terraplanismo e o apelo à experiência pessoal como critério epistemológico. *Caderno Brasileiro de Ensino de Física*, *37*(3), 1173-1192. https://doi.org/10.5007/2175-7941.2020v37n3p1173

Messeder Neto, H. D. S., & Moradillo, E. F. (2020). Uma análise do materialismo histórico-dialético para o cenário da pós-verdade: contribuições histórico-críticas para o ensino de Ciências. *Caderno Brasileiro de Ensino de Física*, *37*(3), 1320-1354. https://doi.org/10.5007/2175-7941.2020v37n3p1320

Moura, C. B., Alsop, S., Camel, T., & Guerra, A. (2023). Science education in a world in crisis: Contributions from the South to a defense of a cultural–historical approach in science teaching. *Cultural Studies of Science Education, 18*(3), 669-693. https://doi.org/10.1007/s11422-022-10129-0

Moura, C. B, Nascimento, M. M., & Lima, N. W. (2021). Epistemic and Political Confrontations Around the Public Policies to Fight COVID-19 Pandemic. *Science & Education*, *30*, 501-525. https://doi.org/10.1007/s11191-021-00193-3

Osborne, J. & Pimentel, D. (2023). Science Education in an Age of Misinformation. *Science Education, 107*(3), 553-571. https://doi.org/10.1002/sce.21790.

Osborne, J., Zucker, A., & Pimentel, D. (2023). Tackling Scientific Misinformation in Science Education. Stanford, United States of America: Stanford University. Recuperado de https://sciedandmisinfo.stanford.edu/sites/g/files/sbiybj25316/files/media/file/tackling_misinformation_in_science_education_osborne_zucker_pimentel.pdf

Oxford Dictionary. (2016). Oxford Dictionary 2016 Word of the Year. Recuperado de https://en.oxforddictionaries.com/word-of-the-year/word-of-the-year-2016

Parthasarathy, Shobita. (2020). Innovation Policy, Structural Inequality, and COVID-19. *Democratic Theory, 7*(2), 104–9. https://doi.org/10.3167/dt.2020.070213

Pereira, A., & Junior, P. L. (2014). Implicações da perspectiva de Wertsch para a interpretação da teoria de Vygotsky no ensino de Física. *Caderno Brasileiro de Ensino de Física*, *31*(3), 518-535. https://doi.org/10.5007/2175-7941.2014v31n3p518

Pereira, A., Ostermann, F., & Cavalcanti, C. (2009). O ensino de Física Quântica na perspectiva sociocultural: uma análise de um debate entre futuros professores mediado por um interferômetro virtual de Mach-Zehnder. *Revista electrónica de enseñanza de las ciências*, *8*(2), 376-398. Recuperado de http://reec.uvigo.es/volumenes/volumen08/ART1_Vol8_N2.pdf

Pivaro, G. F., & Girotto Júnior, G. (2020). O ataque organizado à ciência como forma de manipulação: do aquecimento global ao coronavírus. *Caderno Brasileiro de Ensino de Física*, *37*(3), 1074-1098. https://doi.org/10.5007/2175-7941.2020v37n3p1074

Queiroz, M. (2010). A pipa e os quatro significados da mediação sociotécnica: articulações possíveis entre a

educação e a psicologia para o estudo de um brinquedo. *Revista Brasileira de Pesquisa em Educação em Ciências*, *10*(2). Recuperado de https://periodicos.ufmg.br/index.php/rbpec/article/view/3982

Ranniery, T., Telha, R., & Terra, N. (2020). Educação Científica, (Pós)Verdade e (Cosmo)Políticas das Ciências. *Caderno Brasileiro de Ensino de Física*, *37*(3), 1120-1146. https://doi.org/10.5007/2175-7941.2020v37n3p1120

Rezende, F. & Ostermann, F. (2020). Hegemonic and Counter-Hegemonic Discourses in Science Education Scholarship from the Perspective of Post-Critical Curricular Theories. *Cultural Studies of Science Education, 15*(4), 1047–65. https://doi.org/10.1007/s11422-019-09969-0

Rosa, G. G. (2022). *O princípio da incerteza entre posição e momentum na teoria quântica não-relativística: gênese e estabilização no contexto pedagógico-científico*. (Dissertação de mestrado). Programa de Pós-graduação em Ensino de Física, Universidade Federal do Rio Grande do Sul, Porto Alegre, RS. Recuperada de https://lume.ufrgs.br/handle/10183/240380

Rosa, G. G., Lima, N. W., & Calvacanti, C. J. H. (2023). De que cidadania estamos falando? Uma revisão de literatura das pesquisas em educação em ciências com perspectiva de formação para cidadania. *Ensaio Pesquisa em Educação em Ciências (Belo Horizonte)*, *25*, e45653. https://doi.org/10.1590/1983-21172022240158

Rosa, K. D., Alves-Brito, A., & Pinheiro, B. C. S. (2020). Pós-verdade para quem?: fatos produzidos por uma ciência racista. *Caderno brasileiro de ensino de física*, *37*(3), 1440-1468. https://doi.org/10.5007/2175-7941.2020v37n3p1440

Santana, U. S., & Sedano, L. (2023). Estruturação de perguntas no ensino de ciências por investigação uma proposta visando a alfabetização científica. *Alexandria*, *16*(1), 207-234. https://doi.org/10.5007/1982-5153.2023.e87409.

Silva, R. R. C., Calefi, P. S., & Coutinho, F. Â. (2018). Desvendando as caixas-pretas da ciência: Uma análise do discurso e dos jargões utilizados por estudantes de iniciação científica. *Revista Hipótese*, *4*(4), 412-425. Recuperado de https://revistahipotese.editoraiberoamericana.com/revista/article/view/373

Silva, T. T. (2010). *Documentos de Identidade: Uma Introdução Às Teorias Do Currículo*. Belo Horizonte, MG: Autentica.

Souza, J. D, Rezende, F., & Ostermann, F. (2016). Apropriação discursiva de modelos de formação docente em trabalhos de conclusão de um mestrado profissional em ensino de física. *Ensaio Pesquisa em Educação em Ciências (Belo Horizonte)*, *18*, 171-199. https://doi.org/10.1590/1983-21172016180208

Stengers, I. (2010). *Cosmopolitics*. Minneapolis, United States of America: University of Minesota Press

Stengers, I. (2018). A Proposição Cosmopolítica. *Revista do Instituto de Estudos Brasileiros*, *69*, 442–64. https://doi.org/10.11606/issn.2316-901X.v0i69p442-464

Stetsenko, A. (2008). From relational ontology to transformative activist stance on development and learning: Expanding Vygotsky's (CHAT) project. *Cultural Studies of Science Education*, *3*, 471-491. https://doi.org/10.1007/s11422-008-9111-3

Teixeira, M. D. R. F. (2011). *Redes de conhecimento em ciências e o compartilhamento do conhecimento*. (Tese de doutorado). Programa de Pós-graduação em Educação em Ciências. Universidade Federal do Rio Grande do Sul, Porto Alegre, RS. Recuperado de https://lume.ufrgs.br/handle/10183/37041

Venturini, T. (2010). Diving in magma: how to explore controversies with actor-network theory. *Public understanding of science*, *19*(3), 258-273. https://doi.org/10.1177/0963662509102694

Venturini, T., Munk, A. K., & Jacomy, M. (2019). Actor–network versus network analysis versus digital networks are we talking about the same networks. *Digital STS: A field guide for science & technology studies* (pp. 510-524). Cambridge, United States of America: MIT Press

Wertsch, J. V. (1985). *Vygotsky and the social formation of mind*. London, England: Harvard University Press.

Wertsch, J. V. (1991). *Voices of the mind: Sociocultural approach to mediated action.* London, England: Harvard University Press.

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