

Article

Biodiversity and Citizenship in an Argumentative Socioscientific Process

Anne Caroline de Freitas ^{1,*}, Larissa Aine do Nascimento ¹, Rafael Gil de Castro ², Marcelo Tadeu Motokane ³
and Pedro Reis ⁴

¹ University of São Paulo Interunit Graduate Program in Sciences Teaching, São Paulo 05508-220, Brazil

² Secretaria Municipal da Educação, Ribeirão Preto 14025-000, Brazil

³ Faculdade de Filosofia Ciências e Letras, Universidade de São Paulo (USP), Ribeirão Preto 05508-080, Brazil

⁴ Instituto de Educação, Universidade de Lisboa, 1649-013 Lisbon, Portugal

* Correspondence: anne.freitas@usp.br

Abstract: Socio-environmental issues become evident in countries with megadiversity. Brazil finds itself in this context, adding to the fact that it has severe socioeconomic inequalities, of which we highlight the lack of environmental justice. The present study has education for citizenship and biodiversity as its principles, considering that this interface empowers the students to emerge from socio-political perspectives to overcome environmental injustices. The objective is, therefore, to identify concepts of biodiversity and citizenship present in arguments developed by high school students in a socioscientific discussion. The research participants were nine students from a rural and public school in Brazil. We designed and implemented a Focus Group on the disappearance of bees and its consequences. The participants' speeches were structured in arguments and analyzed from categories regarding the dimensions of citizenship and biodiversity. We identified the relationship among all categories in the arguments listed. However, we observed that these students are not full citizens since they identify several obstacles to active participation in social transformation actions. This study aims to contribute to research and science education strategies to promote active citizenship and critical perspectives on biodiversity.

Keywords: biodiversity; citizenship; socioscientific issues; argumentation



Citation: de Freitas, A.C.; do

Nascimento, L.A.; de Castro, R.G.;

Motokane, M.T.; Reis, P. Biodiversity

and Citizenship in an Argumentative

Socioscientific Process. *Sustainability*

2023, 15, 2987. [https://doi.org/](https://doi.org/10.3390/su15042987)

10.3390/su15042987

Academic Editor: Tarah Wright

Received: 11 December 2022

Revised: 27 January 2023

Accepted: 31 January 2023

Published: 7 February 2023



Copyright: © 2023 by the authors.

Licensee MDPI, Basel, Switzerland.

This article is an open access article

distributed under the terms and

conditions of the Creative Commons

Attribution (CC BY) license ([https://](https://creativecommons.org/licenses/by/4.0/)

[creativecommons.org/licenses/by/](https://creativecommons.org/licenses/by/4.0/)

4.0/).

1. Introduction

Since the 1960s, studies on socio-environmental issues have characterized and questioned the relationship between human beings and their respective social, economic, political, and cultural contexts [1,2]. The loss of biodiversity is associated with the loss of well-being: “it causes disease outbreaks, risks to food, water, and climate security, natural disasters, impoverishment, and marginalization of human populations” [3] (p. 5). The Brazilian Platform on Biodiversity and Ecosystem Services (BPBES) highlights that, as a biodiverse country, we should live without inequality [3]. However, we observe the opposite: the absence of public conservation policies and people exclusion, especially the poor, indigenous, and Quilombola people [4], whereas it is in the territory of indigenous people and Quilombos that we find greater biodiversity [5,6]. These works raise criticisms and discussions about the rights and duties linked to the environmental theme [7]. Guidelines and social movements placed these discussions in a political and collective field [7], which required actions from/within the public domain and revealed the importance of understanding the role of citizens in the face of environmental issues [8].

Currently, the Post-2015 Agenda aims to comply with the Sustainable Development Goals (SDGs) [9–11], which strengthen the various socio-environmental actions sought since the mid-twentieth century. To achieve this goal, it is necessary to change paradigms in how we act within and around the world. In this study, we understand that an efficient way to overcome this paradigm is quality education, as proposed in SDG4: Quality Education [9],

which favors a deepening of citizens' education while highlighting the importance of other SDGs. As will be discussed later, this study considers this goal as a great axis since it approaches skills and knowledge in an integrated way, noticing critical transformations aligned with social and economic ways of life and human rights to achieve environmental justice. In this study, we understand that we must privilege educational actions that seek to unveil the oppressions and overcome them from the protagonism and belonging in their locality to promote this SDG; here, we highlight Latin America and global south countries, such as Brazil, as a focus.

In megadiverse countries, these goals become even more notorious, especially when we observe that the world's greatest wildlife and biodiversity loss has been happening in central/south America [12,13]. In addition to harboring severe socioeconomic inequalities, Brazil is in this situation, including environmental injustice [3,14]. According to [15], the lack of environmental justice reveals itself in unequal situations of exposure to environmental and social risks, which result from the logic of accumulating economic resources and which, therefore, lead to the environmental penalty of the most vulnerable.

The discussion about environmental justice, or its absence, is comprehensive and complex, with several aspects to be considered in the economic, cultural, social, ethnic-racial, ethical, and political spheres. To [16], the knowledge and action that permeate these spheres help the citizens' education, aiming at a status of justice and equity. The idea of citizenship is present during discussions on environmental justice since, in the field of justice, the role of the citizen is of fundamental importance.

Institutions that aim to raise awareness of biodiversity management are at the center of discussions about the importance of citizenship in environmental justice since these are of great importance in creating more sustainable interactions with the environment [8,17,18]. Among these institutions, the school stands out. According to [19], the educational actions developed at school must exist between environmental problems and the demand to establish new bases of knowledge and values. For this, it is necessary to promote knowledge and reflection on the different dimensions that involve biodiversity, recognizing its breadth and complexity. Therefore, approaching the theme in the educational context implies unveiling and problematizing, from a relational perspective, the functional, genetic, and phylogenetic dimensions of biodiversity [20].

Considering the need to discuss socio-environmental issues in the school context to highlight the injustices present in different segments of society, in addition to the promotion of critical individuals capable of acting in the face of such issues, great potential is seen in science education [21,22]. This subject is in a privileged position to foster the discussion of socioscientific themes.

Argumentation occupies a relevant position among the skills required for science education in the context mentioned above [23]. The importance of argumentation as a linguistic resource is well known, given its wide insertion in the social field and the subjects' discourse, and it is in the discourse that cultural meanings are elaborated and the idea of belonging and identity is projected [24]. Therefore, skills such as recognizing and listing data, warrants, and claims in the face of existing problems are part of the subject's construction and its cultural discourse, helping to formulate a critical understanding of reality and being and acting in it from a collective and critical perspective. Therefore, to argue is to make explicit values, cosmovisions, and identities in the construction of the feeling of belonging, a key aspect of citizenship [7,16,25].

The research of [26] reveals the importance of having a dialogic relationship between views of citizenship and science education's objectives, strategies, and methods. For example, we cite the discussions related to biodiversity management, which are suggested as a trend to promote education for citizenship [26]. However, the study by [27] points out that little of this relationship among topics is effectively applied in pedagogical practice. Although there are curricular proposals aimed at critical citizenship, many didactic actions end up in content and technical proposals, which give little space to skills such as the

problematization of reality and argumentation, distancing themselves from a dialogical perspective that aims to question and act in situations of environmental injustice.

We aim to contribute to studies related to citizenship and science education that focus on education for biodiversity. To achieve this, we applied a focus group of high school students, who raised arguments about the disappearance of bees and the relationship of this fact with economic, cultural, social, and scientific aspects. In this sense, the present study aims to identify conceptions of biodiversity and citizenship in the arguments developed by high school students during a socioscientific discussion.

1.1. Biodiversity and Science Education

The author of [28] points out inadequate perceptions of society regarding biodiversity's ethical aspects, which leads to limited management of biodiversity, as well as several gaps to address the issue in the educational sphere. Given these restricted understandings of biodiversity, it is necessary that educational areas, namely science education, bring together different aspects and visions, including issues of justice and ethics [29].

According to [30], there are three different ways of understanding education for biodiversity according to the diversity of values linked to the concept: (i) promoting the understanding of oneself and the environment; (ii) promoting the understanding of the intrinsic relationships between organisms and their ecosystems, questioning the human stance in these relationships; (iii) promoting a critical understanding of reality to increase the equitable distribution of natural resources and an international policy. Consequently, education for biodiversity can integrate aspects beyond the conservation of biological heritage, also becoming a goal of citizenship education. However, the education for biodiversity is often restricted to understanding terms and concepts, remaining disconnected from political, social, and economic issues, presenting the problems linked to biodiversity in a fragmented way, distant from citizens, and leading to superficial and technical views [31].

To counteract fragmented education, the studies must seek to increase citizens' awareness of socio-environmental rights for all social, economic, and cultural groups. This perspective is very important for the Brazilian context, in which biodiversity is part of citizens' rights and, consequently, is based on the field of political and social dispute. The Brazilian Constitution legally provides that everyone has the right to an "ecologically balanced environment, a good for the common use of the people and essential to a healthy quality of life, imposing on the public power and the community the duty to defend and preserve it for present and future generations" [32] (p. 131). Therefore, biodiversity also needs to be part of a science education that is critical and engaged in overcoming environmental injustice.

For [33], the movements for environmental justice and pressing for education curricula are more affirmative of these collective identities. According to the author, it is necessary to propose basic contents and curricula that address the diversity of identities and worldviews. For this, educational institutions must aim to educate citizens who can identify, understand, problematize, and argue about environmental injustices, the dimensions of biodiversity involved, and the consequences for society.

In this context, ref. [34] emphasizes science education as the scenario to overcome hegemonic conceptions and oppressions. The authors point out that it is essential to think about science education in this dialogical relationship with society and political transformation. For [35], the interest in approaches that bring citizenship education closer to science education is based on the need to educate citizens capable of responsibly and critically understanding the issues of their society, based on scientific knowledge.

Therefore, knowing that biodiversity in our country is a matter of environmental justice, citizens must understand the importance of conserving different dimensions of biodiversity and demand democratic, fair, and responsible management for different social and cultural groups.

1.2. Citizenship and Education

The authors of [36] stress that special attention must be given to the repetitive and constant appearance of terms such as “education for citizenship” in curricular guidelines since these discourses may be linked to initiatives to rebuild a policy of trust between government and society. This insistence on documents may relate to the fear that a society that questions public actions will develop, which, according to [27], threatens groups that hold back economic power. Given this possibility, science education must consider the political/economic situation of the nation to avoid the reproduction of a purely economic discourse.

For citizenship not to be restricted to curricular guidelines, the existence of an in-depth understanding of citizenship is important since restrictive views can result in depoliticized pedagogical actions [37]. In this sense, it is necessary to delimit the concept of citizenship. For [38], the definition is imposed unilaterally or scaled up by members of civil society. According to [39], social demands have expanded the concept, seeking to ratify the importance of being linked to a democratic perspective of common rights and responsibilities. Therefore, the democratizing understanding of the theme can create an awareness of belonging and active community participation. The author of [16] proposes that society should configure itself justly so its members recognize its legitimacy and build a collective identity. In this context, citizenship theory can be equated to principles of justice and belonging. According to the citizenship view exposed, we consider the concept proposed by the author [16] in her book *Citizens of the world: for a theory of citizenship*. To [16], the citizen understands and cooperates in favor of common goods in the face of the relational complexity of the dimensions inherent to his role as a citizen: social, political, intercultural, economic, and civil. Therefore, citizenship must integrate a legal status, a set of rights; a moral status, a set of responsibilities; and an identity through which the person feels belonging to a certain society [16].

We consider that each dimension adds to the recognition and problematization of the environment. In this way, the civil and social dimensions enable reflection and action in the face of rights and responsibilities—private and public—regarding the socio-environmental problem. The political and economic dimensions make it possible to break the silence of those affected by these instances based on questioning and action in decision-making on biodiversity. Thus, the intercultural dimension is revealed, which becomes evident in the plural social systems shared by different cultural groups. Therefore, this inherent multiculturalism demands the recognition and participation of these certain agents in their different contexts in constructing identity and decision-making about socio-environmental problems [16,34,40].

In the Brazilian scenario, we live in several situations marked by socio-environmental injustices that urgently require citizen education from a [41] perspective, promoting reflection on the rights and duties regarding the environment. In this context, the aim is to develop the critical citizen, who questions injustices and bases his position on socio-environmental problems [22,42]. Therefore, it is axiomatic to value a responsible conception in the development of these citizens, enabling them to understand and criticize the structures of power in the different dimensions of citizenship, seeking to expand the quality of life at the individual and collective level [37,43–45].

According to [21], students should act responsibly on environmental, economic, social, and ethical aspects. To achieve this, studies indicate an education for citizenship, considering the political aspects of teaching [16,21,46]. In addition, pedagogical practice must be committed to citizens’ participation, opposing the feeling of powerlessness [22,47]. The authors of [34] propose that to approach this citizens’ awareness, science education must integrate the specific issues of the student’s location/context with structural and hegemonic issues in their society.

Given this, the present work defends a commitment to education for citizenship as an emancipatory and collective context, aiming to question and overcome latent unequal relationships in society. We align with Freire’s educational perspectives, considering education for and in a world in which social controversies are unveiled and problematized [41].

According to [41], humanized educational actions must aim to liberate oppressive structures; they must go beyond technical practices. For this, the pedagogical praxis must allow individuals to reach positions of power through scientific knowledge.

2. Materials and Methods

This study aims to identify conceptions of biodiversity and citizenship in the arguments developed by high school students during a socioscientific discussion. This research followed a qualitative perspective and consisted of an observational case study [48,49], since the research is exploratory in nature. This way, the obtained data are context-dependent, aiming to describe aspects inherent to the specific situation and delineate the didactic actions more adequately suited to that context [48]. The process of the research follows the principles of social research as proposed in [49,50]. It is noteworthy that all research is guided by a constant and extensive review of the literature, as proposed by [49,51]. The workflow of this process is summarized in Figure 1.

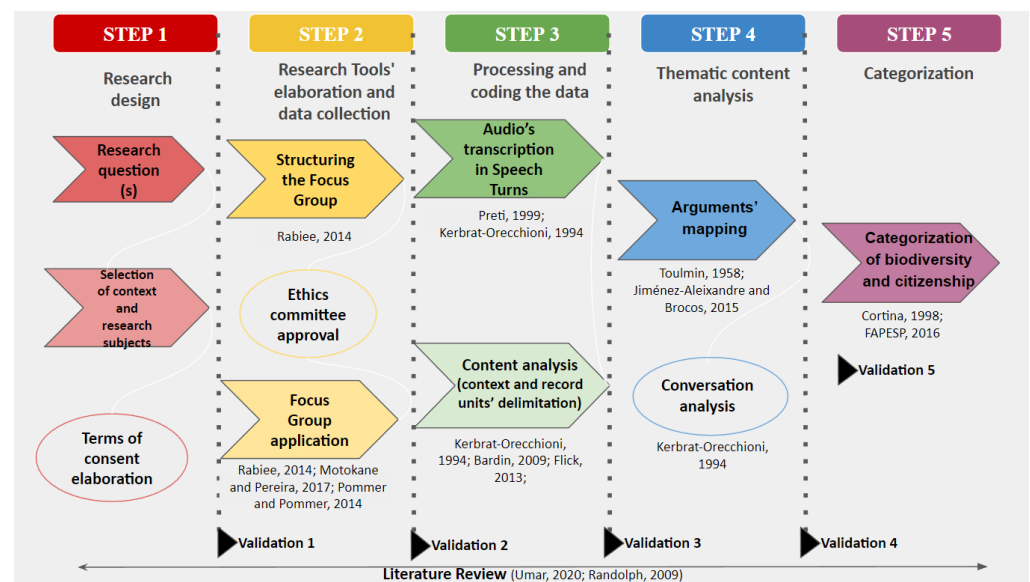


Figure 1. Study procedure flow chart [16,49,51–61].

The first step was to design the research, selecting the context and subjects of our research (Figure 1). We collected the data inside the classroom with a group of nine students from the second year of high school (between 15 and 17 years old, randomly selected). We proposed the number of students according to [52], who consider the optimum number of participants to be between six and ten, aiming to maintain a variety of perspectives at the same time that the focus of the discussion remains. The teacher and coordinator, of the school's only first- and second-year classrooms, randomly selected the group.

We chose the students' age range due to the complexity of the content covered and the suitability of the topic to the Brazilian biology curriculum. The study follows Resolution No. 466/2012 of the National Health Council on Research with Human Beings, approved by the Ethics Committee of Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto-USP (protocol code 10039419.2.0000.5407; date of approval: 23 July 2019).

We selected the school for this research from a list of our research group partners that have authorized us to research with them since 2013. This school is in a rural area with 8.143 inhabitants and only one public high school. The city has industrial and agricultural production areas surrounding it, mainly sugar cane and peanut plantations, which are the basis of their economic and agricultural production. Consequently, the school community lives under pressure from agribusiness, which has made educational efforts to enhance the interests of the rural economy, such as lectures and pedagogical materials emphasizing agribusiness and neglecting the environmental and labor issues involved in

this economic chain. This context leads to the omission of deeper discussions regarding socio-environmental issues. It is also worth mentioning that they belong to a socioeconomic group with few resources and a history of migrating from the country's northern and northern Brazilian regions; some of the students were literate only after ten years old, and many of them go to school to have a meal.

The second step of this research was the research tools' elaboration and data collection (Figure 1). Our research group produces didactic materials and research tools based on dialogue and requirements from schools, which can be described in three stages of production: "Research phase," "Practice phase," and "Dialogic phase" [62]. The researchers dialogue with the teachers, pedagogical coordinators, and school principals. In addition, there are incursions into the school to learn about the subjects' realities involved in that teaching and learning process. These materials are produced from the observations and data collected. The initial production goes directly to the professor, who analyzes and adapts the material according to his criteria. After the application of the class, the material returns to the researchers for further reformulation. The production, validation, and application of the focus group followed these assumptions.

The Focus Group was the method used for data collection. According to [53], this methodology enables the debate of emerging societal situations and stimulates positioning among the participants, promoting the externalization of spontaneous conceptions arising from this process. A mediator is needed to hold a focus group to encourage a discussion based on generating issues and promote a focused and spontaneous discussion [54,63]. This research had two mediators in the Focus Group, interacting and ensuring that the subjects took a stand and built their arguments.

The guiding questions of this Focus Group addressed the socioscientific problem of the disappearance of bees and its consequences [55]. The analyzed data comprise part of this discussion, focusing on the bee's disappearance and its effects on the environment. To start the discussion, we presented two videos. The first one was about the campaign "Bee or not to be," which discussed the importance of preserving bees. The second video consisted of excerpts from the sixth episode of the third season of the Netflix series "Black Mirror," which addressed the possibility of using robot bees in the context of the disappearance of these insects. Thus, students should reflect on and question the consequences of using this technology.

The next step was processing and coding the data (Figure 1). Firstly, we transcribed the speeches from the Focus Group's audio recording according to the orientations in [55]; secondly, we organized them into speech turns (ST) (our record units—term detailed in the next paragraph), according to [56], which generated a total of 355 speech turns. Speech turns are the enunciation per subject; therefore, ST1 is a subject starting to speak, ST2 is another subject starting, and so on. We highlight some representative examples of them in the Supplementary File ST(x).

Then, we used the content analysis proposed by [55–59,64] to code our data. According to [59], this method focuses on manifest meaning by following a systematic description of data using a coding frame, generating category definitions, and segmenting the material into coding units. For reliability assessment, the quality criteria are consistency and validity. We used as context units the guiding questions of the focus group, such as "What is the importance of bees for biodiversity and citizenship?" and "What can we do to change the 'disappearing of bees' scenario?" We considered the record units as the students' speech turns. That is to say, we used this methodology to process and finalize the organization of the students' speeches. Therefore, we first looked for what they were talking about, using only the lines that were addressing the questions (context units), and later, we organized them in speech turns (ST—context units). Non-representative speech turns, those that do not fit the agenda discussed, were removed from the analysis (e.g., speeches regarding the temperature of the air conditioning; random comments), as well as overlapping and/or inaudible speeches.

Subsequently, since this is a horizontal discussion in terms of power relations, the discussions made by the students and their speech turns can be difficult to analyze [56]. Therefore, we need to find thematic content analysis [55–59,64], step four of our research; for this, we use Toulmin’s Argument Pattern—TAP adaptation [65], which was the criterion for extracting the categories (Table 1). Therefore, in this study, the arguments constitute the central unit of analysis. That is to say, arguments will be categorized according to their discussion content.

Table 1. Categories used to analyze the concept of biodiversity.

Category	Description
Functional Biodiversity	When the students portray roles that organisms play within populations, communities, and ecosystems; interaction with ecological processes; the role of these relationships in the generation and maintenance of biodiversity.
Phylogenetic Biodiversity	When the students portray evolutionary processes in the relations of species, features of appearance, and extinction of living beings; considers different species (taxonomy aspect).
Genetic Biodiversity	When the students portray genetic components in the maintenance of biodiversity; addresses aspects related to the variability of genes within the species or populations.

Source: Prepared by the authors.

We based our conclusions on the structural analysis of the argument, according to the contributions of [60]. For the research, an argument was one that included data (which supports the conclusion and has an empirical nature), warrants (which have an explanatory character and mean to conclude the data), and claims (an assertion to be defended) [60]. In the analysis, it was also possible to delimit another element of the argument, the rebuttals, which explain the conditions for a given claim to be valid [60]. Inferred elements are those that do not appear explicitly in the subjects’ speeches and were considered by the researchers based on their dialogical ideas considering the entire subjects’ speech content.

We highlight some limitations of TAP’s uses in school contexts: Ref. [66] stated that the TAP does not consider the context of the construction of arguments (process); warranties are normally implied; during classroom discursive interactions, there is no linearity in the construction of arguments; [67,68] reported difficulty finding the warrant and backing elements of the TAP in classes whose theme is related to a socioscientific issue.

To support the data analysis, we analyzed the speech turns and the arguments following the methodological guidelines of [56] for conversation analysis. This type of analysis, with a qualitative approach, is based on the analysis of verbal and non-verbal interaction shifts. In the case studied, the conversation has elements such as phrases and words that can be classified into categories built a priori. According to [56], conversations have a small number of participants who have the same rights and duties and dialogue for the pleasure of exchanging experiences, ideas, and information. These moments of interaction are used in the construction of the data.

It is worth considering that within the Focus Group, more than one argument can emerge; this configuration is due to the collaborative nature of the argumentative process investigated here. Collaborative, dialectical, or dialogic arguments require the interface of different perspectives, and it is expected that participants share perceptions and ideas [69]. During the interaction with other information and positions of other participants, these perceptions can be restructured and resigned [70]. Therefore, the arguments of this study cover the perspective of a collaborative argumentative process [61], involving interactions of speeches by different subjects throughout the entire interaction of the Focus Group, running from ST1 to ST 355.

After that, we investigated the arguments’ content in terms of the dimensions of biodiversity and citizenship as step five of our research (Figure 1). For this, we used

analytical categories delineated from the particularity of the data obtained and based on the literature. Therefore, the categories arising from extensive literature reviews, involving the comparison of a set of literature against an established set of criteria [49,51], were the dimensions of citizenship and biodiversity; we considered the revision proposals by [16,71] (Tables 1 and 2).

Table 2. Categories used to analyze the concept of citizenship.

Category	Description
Economic Citizenship	When the students portray issues involving the production, distribution, and monetization of consumer goods and services; the role of private and public business institutions in economic management.
Social Citizenship	When the students portray rights and duties for collective goods (e.g., health, environment, education).
Civil Citizenship	When the students portray responsibilities and rights related to everyday life at an individual level for the practice of the common good; aim at the trial of civility, social participation, and solidarity.
Intercultural Citizenship	When the students portray implications of different social, economic, and cultural groups in society.
Political Citizenship	When the students portray political rights; questions regarding government measures; norms and public duties to live in a community based on legislation.

Source: Prepared by the authors.

It is essential to note that the entire study was planned and codified according to [62]. Our research group comprises academics and teachers of primary and higher education. Coding and validation are carried out based on rounds of group analysis by these specialists, which are then debated and reviewed by the researchers.

3. Results

The first argument identified in the students' discourse deals with the discussion about the importance of bee preservation (Figure 2). For this, the students discussed five aspects that characterized the "data" of the argument. These aspects evidence the search for evidence for the claim of the argument. Within this argument, the students considered the following as given: the disappearance of bees, the pollination process, the importance of food production, species diversity, and the implementation of robots. These data corroborate the claim about the importance of bee preservation (Figure 2). This conclusion was justified in six topics (Figure 2), with scientific content on areas of biology and aspects related to citizenship. As a rebuttal, the participants pointed out that the population will not consider preservation if they are not aware of the problem.

Figure 3 presents a summary of the categorized contents and the relationships with the elements of the arguments. We noted the appearance of categories in each element of the argument (Figure 2), representing the dimensions of citizenship and biodiversity found throughout the discussion (Figure 3).

The second argument analyzed refers to the discussion about the possibilities of actions to avoid the extinction of bees, according to the question, "Is it possible to do something to change this situation of the disappearance of bees in our society?" In this argument, the students relativized their role as citizens, listing the main obstacles to acting on the subject in question. Participants revealed a difficulty in being heard and discrediting the ability of youth to interfere in the issue debated. Participants claim that the actions that can effectively solve the problem of the disappearance of bees must come from people older than themselves or representatives elected by them.

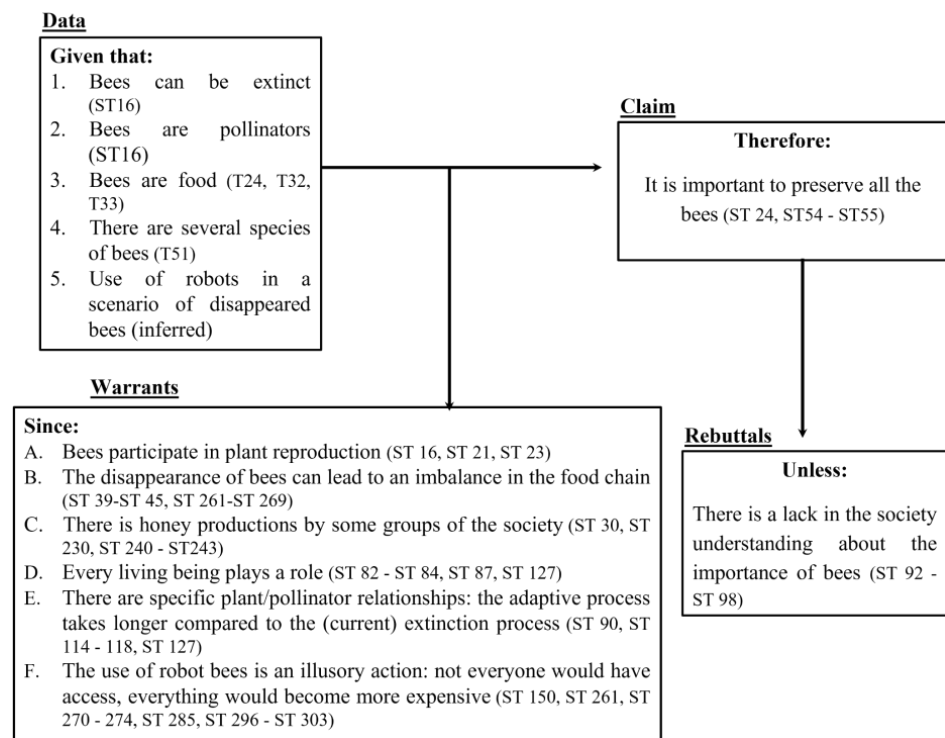


Figure 2. Structural analysis of argument one found in the first episode of the Focus Group. The major representative students’ speech shifts used to elaborate this argument can be found in the Supplementary File—ST(x): Speech turns.

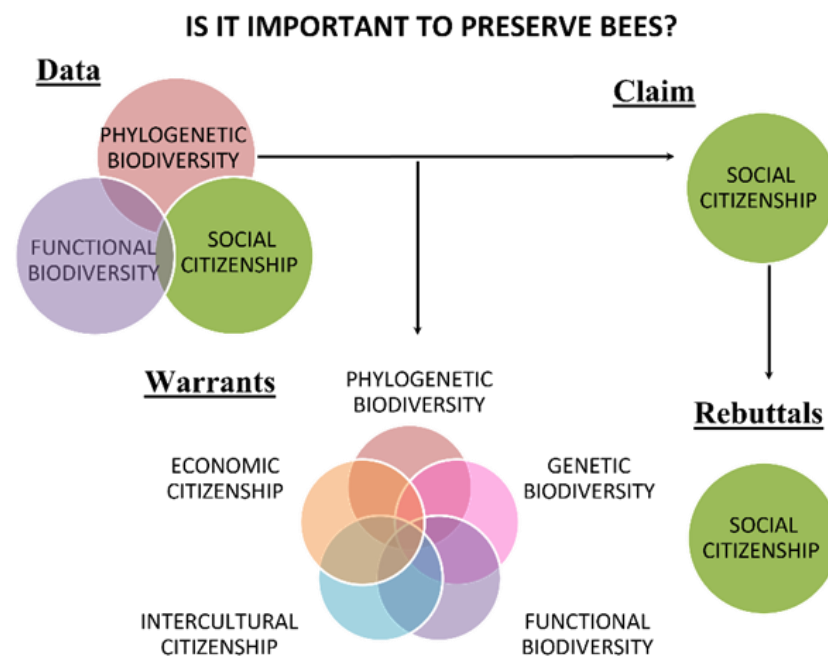


Figure 3. Summary of the content discussed in each element of argument one, considering the categories of biodiversity and citizenship.

For this, the students specified three main questions that characterize the data. These aspects reflect the subjects’ perceptions regarding the representation of young people, as listed in Topics 1 through 3 of Figure 4. From these considerations, the students concluded that preserving bees is difficult since the decision-making power and the actions that can effectively solve the problem of bee extinction are restricted to specific groups in society

and not to youth. Four justification topics support this argument, which outlines reasons and influences for the restriction of the active community.

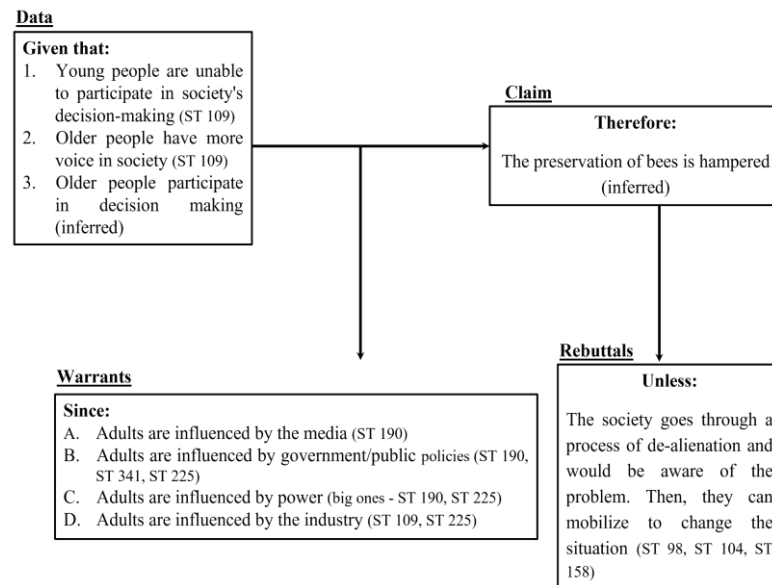


Figure 4. Structural analysis of Focus Group argument two. The major representative students’ speech shifts used to elaborate this argument can be found in the Supplementary File ST(x): Speech turns.

From the moment that society’s knowledge on the subject changes (“rebuttal”), it is possible that they reach collective measures in favor of an effective transformation in the preservation of bees. For this, members of society must have scientific knowledge of the problem, go through a process of building critical thinking, and, finally, be able to fight together for the common good. Figure 4 represents these data.

In this context, the argumentative process permeates the association of different actors and social spheres in dialogue. Such considerations start from different dimensions of citizenship, associating the environmental problem with the influence of other fields of culture, such as the media, government, politics, and industry, among others. In addition, Figure 5 explains the dimensions of citizenship used in the argument.

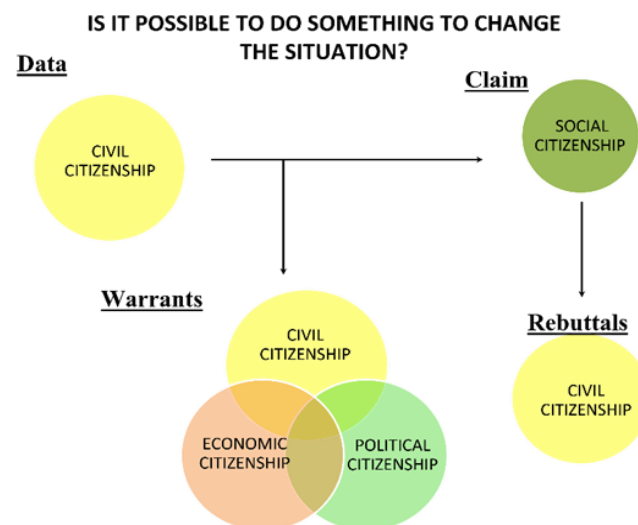


Figure 5. Summary of the content discussed in each element of argument two, considering the categories of biodiversity and citizenship.

4. Discussion

From Figures 3 and 5, we can see that the arguments mobilize the dimensions of citizenship and biodiversity in the argumentative process, which is characterized by different elements.

It is necessary to emphasize the appearance of elements that characterize the phylogenetic dimension of biodiversity (Figure 3). In the context discussed here, this dimension is required and presented as a justification for a position in a socioscientific discussion that is relevant to the teaching of biodiversity.

To understand the phylogenetic perspective in primary education, it is not necessary to use specific methodology and algorithms in the area but to recognize the evolution of specific characteristics of living beings [72,73].

The data in Figures 2 and 3 indicate that students understand the evolutionary processes of adaptation as determinants of the features of living beings and recognize the importance of maintaining specific relationships among species on a temporal scale. Comprehending the theory of evolution by understanding the relations among species is associated with essential areas in science, such as taxonomy.

We observe little usage of genetic biodiversity in the arguments. The students point out the ecological importance of bees in terms of their role in maintaining genetic variability. However, they do not elaborate on their response when required by the mediators. The genetic perception highlighted in the discussion reproduces the gaps associated with teaching these concepts, which may be related to the difficulties in understanding this content in biology teaching, described in the literature as complex and highly abstract for students [74]. The genetic dimension approaches the genetic level of biodiversity [75], thus reflecting the issues raised by [76]. According to the authors, this level of biodiversity presents high conceptual complexity. The author of [77] (p. 100) highlights that understanding biodiversity at a genetic level also requires understanding the concept of species and the very elements of genetics that require a high degree of abstraction, such as “genes, alleles, differentiated reproduction, genetic variability, natural selection, reproductive success, among others”.

For functional biodiversity, we observe aspects associated with the ecological character, a very evident element associated with biodiversity [78]; relationships between beings/environment, predominantly trophic and ecological niches. For [77], understanding the relationships between beings and considering temporal and spatial elements leads to an ecological and evolutionary understanding of biodiversity that is highly complex since it includes several concepts.

Therefore, data analysis points to relationships among the different dimensions of biodiversity as warrant for a conservationist position. For this, students use scientific knowledge to trace the consequences of a specie’s disappearance by associating morphological, behavioral, ecological, physiological, and genetic characteristics. Such perceptions are significant for understanding the breadth and complexity of biodiversity management.

However, The Black Mirror’s episode has a problematic point that was not brought up for discussion in the Focus Group. The honey bees mentioned in the episode are native to the United Kingdom but not to Brazil, and the use of an introduced species can cause several harmful environmental situations and lead to a loss of biodiversity since exotic bees increase seed set and hence the weediness of some exotic plants [79]. This could have been a rich socioscientific discussion due to the trade-offs between a practice that exclusively serves human interests (i.e., agricultural productivity) and the preservation of native biodiversity, including native bees.

Nevertheless, for citizenship issues, it is noteworthy that students point out principles of economic citizenship (Figures 3 and 5). Students questioned the real participation of all members of society who are affected by economic decisions in the decision-making process. They also discuss the lack of democratic access to technologies that supposedly solve socio-environmental problems since the benefits of monetizing products and services are restricted to specific social groups (Figure 2). In addition, they discuss the environmental and social responsibility of industries regarding the expansion of an existing problem in society (Figure 4). From the economic warrants in the argumentative process (Figures 2 and 4),

the students perceive the citizen responsibility of business institutions. In this way, young people bring the idea that “a horizon of legitimation of norms must be established that, applied to the economic and business world, requires that the economic constitution and business norms be decided dialogically, having all affected groups as interlocutors” [16] (pp. 79–80). These considerations characterize a moral conscience and a critique of ethics in the economic sphere [16].

Regarding the social dimension (Figures 3 and 5), it is noticeable that the students discussed managing their social rights, such as food, a balanced environment, and access to information. As proposed in [16], citizens must question how to manage and not lose such rights, aiming at their maintenance and administration. For the author, the access to and the request for human rights are based on the principle of an ethical demand for justice that must be met by the state. In this sense, social citizenship engages in dialogue with issues of the intercultural dimension, encompassing all groups living together in society.

Another aspect is the request for collective action. According to the students, there should be no social group apart from those who understand the problem; everyone should be aware that it is necessary to conserve the environment. As proposed in [16] and highlighted in the students’ speech, the full understanding of social citizenship involves the ethics of justice, which considers that no member of society should be unprotected; otherwise, they are not considered a citizen by that society.

Not feeling like citizens, they cannot fight for their social rights to be considered. These considerations regarding disenfranchisement and a sense of belonging become evident in argument two, mostly in the rebuttal element. In this element, students state that it is only possible to change the scenario of the problem in question if everyone is aware, but for that, everyone must have access to information.

In the conceptualization of civil citizenship, the intrinsic relationship of this domain with political participation (the political dimension) for the maintenance of basic rights (the social dimension) is observed [16]. This conceptualization is also evident in the students’ speeches when they consider that access to information should be available to everyone so that engagement and social and political representation can occur (Figure 4). This understanding of the students is close to what [16] understands by the moral duty of civility. In addition, this perception concerns the democratic consensus of minimum justice (basic rights for a just life), which must be considered in the action of civil associations and the participation of these groups in political issues.

As observed in the students’ speeches, in arguments one and two (the refuting element, see Figure 4), it is worth noting that because it is an environmental asset belonging to the social heritage of all its members, it is necessary to understand the extent of the socio-environmental problem. Based on this understanding, it is possible to promote joint work with the population to maintain this right, considering the political, economic, and intercultural dimensions.

Therefore, despite incorporating all dimensions of citizenship and biodiversity relationally throughout the arguments, students do not feel like full citizens in their society.

The authors of [79] defend the education of a citizen who understands environmental issues, which primarily presupposes information and, substantially, responsibility and action. For this, the authors highlight the importance of recognizing environmental issues in different areas: information; responsibility (civic and supra-individual); and concrete practices.

In the present work, the students constructed the perceptions on these topics proposed by the authors based on the relationship between dimensions of biodiversity and citizenship. In argument one, we observed the mobilization and informational recognition of multidimensional causes as well as local and global consequences of the ecological problem. The searches for individual and collective responsibility in this process are also highlighted, as evidenced in the refuting element and, also, in the justifications. In this argument, however, the possibilities of concrete action in the face of reality are not evident. For [79], ecological knowledge and the determination of responsibilities are not enough; it is also necessary to point out the nature of the environmental issue and take concrete actions in

the face of the problem. This aspect becomes more evident in argument two, in which we only have dimensions of citizenship that surround the delimitation of responsibilities in the face of the impacts of certain actions and inactions in the face of the socio-environmental problem; difficulty in recognizing sufficient information and especially options for action. Students portray this last aspect as a lack of possibilities for the transformation of reality, which culminates in difficulties in overcoming the current oppressive reality, pointing to impotence and passivity.

This fact is associated with the citizenship context in which these students are since they do not access their basic rights and duties. Students find themselves in a scenario highlighted by [80] as “semi-citizenship”. According to the author, this concept is configured in the plural realities of liberal democracies, in which some groups do not have access to the entire package of citizenship rights, causing a disparity among social groups, with some having “more complete” rights than others. Therefore, these subjects are in a situation of citizenship in which they recognize that access to information and participation in environmental issues are restricted to those with greater political and economic power. These perceptions refer to reflections on the neoliberal system into which they are inserted and the perception that their citizenship is reduced to the power of consumption, including discussions of an environmental nature [81]. These data may be related to the actions and interests of big rural producers in a small rural town in the interior of Brazil surrounding the student’s perceptions, which caused much silence, making them objects [41]. In such a way, since they do not access or participate in the environmental discussions, it creates an environment of environmental injustice.

However, the relationship between the dimensions of citizenship and biodiversity in the students’ arguments led to the construction of a discourse dealing with unveiling the environmental issue. That is, the subjects recognized the complexity of the dimensions of biodiversity involved in the problem, using scientific knowledge to reveal reality. At the same time, they constructed questions regarding their rights, tensions, and interests and recognized possible power relations in the different dimensions of citizenship. They are beginning to recognize elements of conflict and, consequently, their distance from socio-environmental discussions. In this context of oppression, where people from the subordinated have a voice [82], as mentioned above, educational actions must promote the recognition and assumption of the socio-cultural identity of individuals, which are essential to educational practice as asked by [83] (p. 42): “The historical, political, cultural and social experience of men and women can never be ‘virgin’ of the conflict between the forces that hinder the search for self-assumption by individuals and groups and the forces that work in favor of that assumption”.

Our data (especially argument two) show this attempt by students to understand the processes of environmental destruction, their consequences, and possible actions, seeking oppressive causes and forces and constructing arguments. They are achieving their processes of liberation and critical insertion into reality dialogically, as well as the impetus to transform it, which are essential factors for the teaching of biodiversity and citizenship that we defend.

The interface of the themes identified in the argumentative process brings robustness to the discussion, constructing well-founded and critical arguments in the face of the socio-scientific discussion. For [31], this critical analysis is extremely relevant, as it makes it possible to re-signify the role of the citizen, the reason for the socio-environmental degradation, the well-being of the agents involved, and citizen participation. Therefore, understanding and revealing these aspects and asymmetries through citizen action enables “a process of reconstruction of knowledge that allows an integrated analysis of reality” [84] (p. 62).

The relationship between citizenship and biodiversity made by the students in argument one shows essential elements of scientific literacy, such as the relationship between science, technology, and society. However, when asked about possible actions, they cannot project a plan to protect the bees. Therefore, these results highlight the need to change the transmissive educational vision of scientific literacy to a transformative one with a more

robust engagement with social participation and emancipation [85–87]. In this sense, it is evident that it is necessary to propose an education that goes beyond simplistic discussions and reaches these young people's effective action in their reality [88]. It is necessary to break with a science education restricted to scientific concepts and technological products without its social implications to overcome passivity in the face of complex socio-environmental problems; it is necessary to empower students in argumentative processes and the authorship of concrete socio-political interventions [22,89–92]. In this way, our data make us question the current science education and prospect initiatives that deconstruct the passivity of this youth in the face of socio-environmental tensions. We agree with [22,47,89] that it is necessary to aim at the engagement of citizens in their society and expand the understanding of current power relations beyond purely ecological terms and concepts. According to [84,86], there is no other way to transform reality than to practice a humanizing pedagogy dealing with socio-political actions [22,89], which, instead of overcoming the oppressed and maintaining them as "things," establishes a permanent dialogic relationship with them.

5. Conclusions

The present work aimed to identify conceptions of biodiversity and citizenship in the arguments of high school students in a socioscientific discussion. It was possible to observe that the students positioned themselves in the argumentative process, and, in addition, they traced relationships between the concept of biodiversity and the concept of citizenship. Data analysis showed that the socioscientific and argumentative character of the Focus Group was essential to promoting the discussion of the different dimensions of citizenship and biodiversity. Throughout the process and from the mediation, we requested data, warrants, and student claims, which triggered argumentative skills involving the different dimensions of citizenship and biodiversity. In this way, the argumentation made it possible for students to engage about current socio-environmental issues, the collective construction of social meanings for biodiversity, transposing common sense discourses, and approaching the possibilities of the exercise of their citizenship.

The results corroborate research in science education that defends argumentation on socioscientific issues as a tool to recognize and discuss domains of the exercise of citizenship. This strategy is relevant because when students understand the biological and social aspects involved, as well as actions to change, they feel a sense of belonging and then consciously participate in the practices and decision-making that involve these issues. Thus, limiting scientific teaching to concepts unrelated to an evident and purposeful socioscientific discussion (transmissive scientific literacy) is insufficient if the objective is education for citizenship based on presuppositions of environmental justice.

In the assumptions of citizenship education, the objective of educational practice is to provide students with the ability to apply youth culture issues to build their civic and moral responsibility. When observing the demands in the speeches of these adolescents regarding their participation in society beyond the individual scope, responsibly and collectively, aspects linked to the propositions of citizen education become evident.

Therefore, studies such as this one—which promotes the characterization of how students conceive their role in managing biodiversity and its relationship with citizenship—can clarify how teaching approaches need to explore these issues (biodiversity and citizenship).

We highlight the limitations of this study, as it is a case study. However, it is necessary to stand out and deepen in cases that analyze how a minority feels in the face of oppression and exclusion from socio-environmental discussions, such as in contexts of small rural towns that are subaltern and dominated by agribusiness interests, especially in the teaching of science/biology. In this sense, case studies such as this one can contribute to the construction of responsible decision-making and a fair society and, consequently, move us closer to the SDG 4 targets and Education for Sustainability, as they reflect. It addresses the impacts of individual and collective actions when considering different futures in cultural,

social, and economic terms (a local-global perspective) and empowers individuals to act in complex situations and socio-political processes from an environmentally fair perspective.

These relationships must be deepened in school practices, especially in socioscientific discussions. It is not enough to work only on the environment-society relationship; it is necessary to reflect deeply on each coexisting dimension as well as the relationships and power interests involved.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/su15042987/s1>, File S1. Main Students' speech turns.

Author Contributions: Conceptualization, A.C.d.F. and M.T.M.; methodology, A.C.d.F., L.A.d.N., R.G.d.C. and M.T.M.; validation, P.R. and M.T.M.; formal analysis, A.C.d.F.; investigation, A.C.d.F.; resources, A.C.d.F.; data curation, A.C.d.F.; writing—original draft preparation, A.C.d.F. and L.A.d.N.; writing—review and editing, R.G.d.C., M.T.M. and P.R.; visualization, A.C.d.F. and L.A.d.N.; supervision, M.T.M.; project administration, M.T.M.; funding acquisition, A.C.d.F. and M.T.M. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior grant number 88882.377542/2019-01.

Institutional Review Board Statement: The study was conducted following Resolution No. 466/2012 of the National Health Council on Research with Human Beings, and approved by the Ethics Committee of Faculdade de Filosofia, Ciências e Letras de Ribeirão Preto-USP (protocol code 10039419.2.0000.5407; date of approval: 23 July 2019).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to acknowledge and give our warmest thanks to all the members of the research group LINCE—Science and Biology teaching, as well as to the CAJUI (Biodiversity, Education and Sustainability) research group, who made this work possible, and to all the professors and students of the institutions who participated in this research.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Ballesteros, J. *Ecologismo Personalista: Cuidar a Natureza, Cuidar al Hombre*; Tecnos: Madrid, Spain, 1985.
- Leff, E. *Ecologia, Capital e Cultura: Racionalidade Ambiental, Democracia Participativa e Desenvolvimento Sustentável*; Editora da FURB: Blumenau, Brazil, 2000.
- Contribuições Para o Diálogo Intersetorial: A Construção do Diagnóstico Brasileiro Sobre Biodiversidade e Serviços Ecossistêmicos. 2016. Available online: https://www.bpb.es.net.br/wp-content/uploads/2018/08/Dialogos_BPES.pdf (accessed on 16 January 2022).
- Souza, A.S. *Direito e Racismo Ambiental na Diáspora Africana: Promoção da Justiça Ambiental Através do Direito*; EDUFBA: Salvador, Brazil, 2015.
- Toledo, V.M.; Barrera-Bassols, N. *A Memória Biocultural: A Importância Ecológica das Sabedorias Tradicionais*, 1st ed.; Expressão popular: Rio de Janeiro, Brazil, 2015.
- RESILIENCE. 2022. Available online: <https://www.resilience.org/stories/2022-05-23/why-the-un-must-rely-more-on-indigenous-wisdom-and-less-on-fossil-fuels/> (accessed on 16 January 2022).
- Silva-Sánchez, S.S. *Cidadania Ambiental: Novos Direitos No Brasil*; Humanitas FFLCH/USP: São Paulo, Brazil, 2010.
- Wyborn, C.; Montana, J.; Kalas, N.; Clement, S.; Davila, F.; Knowles, N.; Louder, E.; Balan, M.; Chambers, J.; Christel, L.; et al. An agenda for research and action toward diverse and just futures for life on Earth. *Conserv. Biol.* **2021**, *35*, 1086–1097. [CrossRef]
- ONU-Nações Unidas Brasil. *Objetivos de Desenvolvimento Sustentável: Sobre o Nosso Trabalho Para Alcançar os Objetivos de Desenvolvimento Sustentável No Brasil*. Available online: <https://brasil.un.org/pt-br/sdgs> (accessed on 6 December 2022).
- Umar, T.; Egbu, C.; Ofori, G.; Honnurvali, M.S.; Saidani, M.; Shibani, A.; Opoku, A.; Gupta, N.; Goh, K. UAE's commitment towards UN Sustainable Development Goals. *Proc. Inst. Civ. Eng.-Eng. Sustain.* **2020**, *173*, 325–343. [CrossRef]
- Umar, T.; Nnedinma, U. Exploring the GCC Progress Towards United Nations Sustainable Development Goals. *Int. J. Soc. Ecol. Sustain.* **2022**, *13*, 1–32. [CrossRef]
- Mittermeier, R.A.; Myers, N.; Thomsen, J.B.; Da Fonseca, G.A.; Olivieri, S. Biodiversity hotspots and major tropical wilderness areas: Approaches to setting conservation priorities. *Conserv. Biol.* **1998**, *12*, 516–520. [CrossRef]
- LatinAmerica Post. Latin America: The Region Where Wildlife Is Lost the Most. 2022. Available online: <https://latinamericanpost.com/42420-latin-america-the-region-where-wildlife-is-lost-the-most> (accessed on 16 January 2022).

14. Castro, F. Multi-Scale Environmental Citizenship. In *Environment and Citizenship in Latin America: Natures, Subjects and Struggles*; Berghahn Books: Oxford, NY, USA, 2012; pp. 39–58.
15. Legarda, A.A.; Buendía, M.P. Justicia Ambiental. El estado de la cuestión. *Rev. Int. De Sociol. (RIS)* **2009**, *69*, 627–648. [[CrossRef](#)]
16. Cortina, A. *Ciudadanos del Mundo: Hacia una Teoría de la Ciudadanía*; Alianza: Madrid, Spain, 1998.
17. Ballouard, J.M.; Brischoux, F.; Bonnet, X. Children Prioritize Virtual Exotic Biodiversity over Local Biodiversity. *PLoS ONE* **2011**, *6*, e23152. [[CrossRef](#)]
18. Pellier, A.S.; Wells, J.A.; Abram, N.K.; Gaveau, D.; Meijaard, E. Through the Eyes of Children: Perceptions of Environmental Change in Tropical Forests. *PLoS ONE* **2014**, *9*, e103005. [[CrossRef](#)] [[PubMed](#)]
19. Carvalho, I.C.M. Educação Ambiental Crítica: Nomes e endereçamentos da educação. In *Identidades da Educação Ambiental Brasileira*; Layrargues, P.P., Ed.; Ministério do Meio Ambiente, Diretoria de Educação Ambiental: Brasília, Brazil, 2004; pp. 13–24.
20. Almeida, E.A.; de Freitas, A.C.; Santos, C.C.; Silva, R.L.; Motokane, M.T.; Franzolin, F. A Biodiversidade nas pesquisas em educação ambiental. *Diálogos Em Educ.* **2017**, *11*, 29–50.
21. Hodson, D. Realçando o papel da ética e da política na educação científica: Algumas considerações teóricas e práticas sobre questões sociocientíficas. In *Questões Sociocientíficas: Fundamentos, Propostas de Ensino e Perspectivas para ações Sociopolíticas*; Nunes-Neto, N., Conrado, D.M., Eds.; EDUFBA: Salvador, Brazil, 2018; pp. 27–57.
22. Reis, P. Environmental Citizenship & Youth Activism. In *Conceptualizing Environmental Citizenship for 21st Century Education Series “Environmental Discourses in Science Education”*; Hadjichambis, A.C., Reis, P., Paraskeva-Hadjichambi, D., Čincera, J., Pauw, J.B.-D., Gericke, N., Knippels, M.-C., Eds.; Springer: Cham, Switzerland, 2020; pp. 139–148.
23. Jiménez-Alexandre, M.P. *10 Ideas Clave: Competencias en Argumentación y Uso de Pruebas*; Graó: Barcelona, Spain, 2010.
24. Hall, S. *A Identidade Cultural na Pós-Modernidade*, 11th ed.; DP&A: Rio de Janeiro, Brasil, 2006.
25. Andrade, M.J.S. O lugar da argumentação na Educação para a Cidadania no contexto da Educação Pré-Escolar e do 1.º Ciclo do Ensino Básico. Master’s Thesis, Universidade dos Açores, Ponta Delgada, Portugal, 15 February 2018.
26. Vesterinen, V.M.; Tolppanen, S.; Aksela, M. Toward citizenship science education: What students do to make the world a better place? *Int. J. Sci. Educ.* **2016**, *38*, 30–50. [[CrossRef](#)]
27. Levinson, R. Science education and democratic participation: An uneasy congruence? *Stud. Sci. Educ.* **2010**, *46*, 69–119. [[CrossRef](#)]
28. Gayford, C. Biodiversity education: A teacher’s perspective. *Environ. Educ. Res.* **2000**, *6*, 347–361. [[CrossRef](#)]
29. Keogh, J.S. The importance of systematics in understanding the biodiversity crisis: The role of biological educators. *J. Biol. Educ.* **1995**, *24*, 293–299. [[CrossRef](#)]
30. Van Weelie, D.; Wals, A.E.J. Making biodiversity meaningful through environmental education. *Int. J. Sci. Educ.* **2002**, *24*, 1143–1156. [[CrossRef](#)]
31. Déjardin, I.P. Cidadania em uma perspectiva multidimensional: Diálogos contemporâneos. *Rev. Direito Ambient. E Soc.* **2019**, *2*, 215–247. [[CrossRef](#)]
32. Brasil Constituição. *Constituição. Constituição da República Federativa do Brasil*; Senado Federal: Centro Gráfico: Brasília, Brazil, 1988.
33. Arroyo, M.G. *Currículo, Território em Disputa*; Petrópolis: Vozes, Brasil, 2013.
34. Oliveira, R.D.V.L.; Queiroz, G.R.P.C. O cotidiano, o contextualizado e a Educação em Direitos Humanos: A escolha de um caminho para uma Educação cidadã cosmopolita. *Rev. Iberoam. De Educ.* **2016**, *71*, 75–96.
35. Bencze, J.L.; Sperlring, E. Student-teachers as advocates for student-led research-informed socioscientific activism. *Can. J. Sci. Math. Technol. Educ.* **2012**, *12*, 62–85. [[CrossRef](#)]
36. Pinhão, F.; Martins, I. Cidadania e ensino de ciências: Questões para o debate. *Ens. Pesqui. Em Educ. Em Ciências* **2016**, *18*, 9–29. [[CrossRef](#)]
37. Giroux, H.A. Cultural studies, public pedagogy, and the responsibility of intellectuals. *Commun. Crit. /Cult. Stud.* **2004**, *1*, 59–79. [[CrossRef](#)]
38. Dean, H. Green Citizenship. *Soc. Policy Adm.* **2001**, *35*, 490–505. [[CrossRef](#)]
39. Rios, T.A. *Compreender e Ensinar—Por uma Docência da Melhor Qualidade*; Cortez: São Paulo, Brasil, 2001.
40. Acselrad, H.; Mello, C.C.D.A.; Bezerra, G.N. *O que é Justiça Ambiental?* 1st ed.; Garamond: Rio de Janeiro, Brasil, 2009; p. 160.
41. Freire, P. *Pedagogy of the Oppressed*, 30th Anniversary ed.; Continuum: New York, NY, USA, 2000; 256p.
42. Cosenza, A.; Freire, L.M.; Espinet, M.; Martins, I. Relações entre justiça ambiental, ensino de ciências e cidadania em construções discursivas docentes. *Rev. Bras. De Pesqui. Em Educ. Em Ciências* **2014**, *14*, 89–98.
43. Conrado, D.M.; de Souza, M.M.O.R.; Cruz, L.M.S.; El-Hani, C.N. Evolução e ética na tomada de decisão em questões socio-científicas. In *Proceedings of the IX Congreso Internacional Sobre Investigación en Didáctica de las Ciencias*, Girona, Spain, 9 September 2013.
44. Giroux, H.A.; Giroux, S.S. Challenging Neoliberalism’s new world order: The promise of critical pedagogy. *Cult. Stud.-Crit. Methodol.* **2006**, *6*, 21–32. [[CrossRef](#)]
45. Santos, W.L.P.; Mortimer, E.F. Tomada de decisão para ação social responsável no ensino de ciências. *Ciência Educ. (Bauru)* **2001**, *7*, 95–111. [[CrossRef](#)]
46. Tan, M. Science Teacher Activism: The Case of Environmental Education. *J. Act. Sci. Technol. Educ.* **2009**, *1*, 32–43.
47. Reis, P. Acción socio-política sobre cuestiones socio-científicas: Reconstruyendo la formación docente y el currículo. *Uni-Pluri/Versidad* **2014**, *14*, 16–26.

48. Bogdan, R.C.; Biklen, S.K. *Investigação Qualitativa em Educação uma Introdução à Teoria e aos Métodos*; Porto Editora: Porto, Portugal, 1994.
49. Umar, T. Key factors influencing the implementation of three-dimensional printing in construction. *Proc. Inst. Civ. Eng.-Manag. Procure. Law* **2020**, *174*, 104–117. [[CrossRef](#)]
50. Bryman, A. *Social Research Methods*; Oxford University Press: New York, NY, USA, 2016.
51. Randolph, J. A Guide to Writing the Dissertation Literature Review. *Pract. Assess. Res. Eval.* **2009**, *14*, 13.
52. Rabiee, F. Focus-group interview and data analysis. *Pro. Nutr. Soc.* **2004**, *63*, 655–660. [[CrossRef](#)]
53. Gatti, B.A. *Grupo Focal na Pesquisa em Ciências Sociais e Humanas*; Liber Livros: Brasília, Brasil, 2005.
54. Pommer, W.M.; Pommer, C.P.C.R. A metodologia do grupo focal e a formação continuada do professor: Um olhar interativo envolvendo a articulação cognição e emoção. *Itinerarius Reflectionis* **2014**, *10*. [[CrossRef](#)]
55. Preti, D. *O Discurso Oral Oculto*, 2nd ed.; Humanitas: São Paulo, Brasil, 1999.
56. Kerbrat-Orecchioni, C. Analyse des conversations et négociations conversationnelles. In *La Négociation au Travail*; Grosjean, M., Mondada, L., Eds.; Pu Lyon: Lyon, France, 1994.
57. Bardin, L. *Análise de Conteúdo*; Edições 70 LDA: Lisboa, Portugal, 2009.
58. Drisko, J.W.; Maschi, T. *Content Analysis*; Oxford University Press: London, UK, 2016.
59. Flick, U. *The SAGE Handbook of Qualitative Data Analysis*; Sage: New York, NY, USA, 2013.
60. Jiménez-Aleixandre, M.P.; Brocos, P. Desafios Metodológicos na Pesquisa da Argumentação em Ensino de Ciências. *Ens. Pesqui. Em Educ. Em Ciências (Belo Horiz.)* **2015**, *17*, 139–159. [[CrossRef](#)]
61. FAPESP. BIOTA-Fapesp. 2016. Available online: <http://www.fapesp.br/6259> (accessed on 27 July 2020).
62. Motokane, M.T.; Pereira, M. Validation and production of inquiry didactic sequences of biology. *Conexão Ciência* **2017**, *12*, 424–427.
63. Mendonça, I.; Gomes, M.F. Grupo focal: Instrumento de coleta de dados na pesquisa em educação. *Cad. De Educ. Tecnol. E Soc.* **2017**, *10*, 52–62.
64. Crowley, B.P.; Delfico, J.F. *Content Analysis: A Methodology for Structuring and Analyzing Written Material*; GAO: Washington, DC, USA, 1996.
65. Toulmin, S. *The Uses of Argument*; Cambridge University Press: New York, NY, USA, 1958.
66. Driver, R.; Newton, P.; Osborne, J. Establishing the norms of scientific argumentation in classrooms. *Sci. Educ.* **2000**, *84*, 287–312. [[CrossRef](#)]
67. Zohar, A.; Nemet, F. Fostering students' knowledge and argumentation skills through dilemmas in human genetics. *J. Res. Sci. Teach.* **2002**, *25*, 685–725. [[CrossRef](#)]
68. Erduran, S.; Simon, S.; Osborne, J. TAPping into Argumentation: Developments in the use of Toulmin's Argument Pattern in Studying Science Discourse. *Sci. Educ.* **2004**, *88*, 915–933. [[CrossRef](#)]
69. Evagorou, M.; Osborne, J. Exploring young students' collaborative argumentation within a socioscientific issue. *J. Res. Sci. Teach.* **2013**, *50*, 209–237. [[CrossRef](#)]
70. Schwarz, B. Argumentation and learning. In *Argumentation and Education: Theoretical Foundations and Practices*; Muller Mirza, N., Perret-Clermont, A.-N., Eds.; Springer: New York, NY, USA, 2009; pp. 91–126.
71. Santos, C.; Calor, A. Ensino de Biologia Evolutiva utilizando a estrutura conceitual da Sistemática Filogenética-I. *Ciência Ensino* **2007**, *1*, 1–8.
72. Amorim, D.S. Diversidade biológica e evolução: Uma nova concepção para o ensino. In *Aulas de Ciências: Projeto LEC-PEC de ensino de Ciências*; Barbieri, M.B., Ed.; Holos: Ribeirão Preto, Brazil, 1999; pp. 9–11.
73. Bugallo Rodríguez, Á. La didáctica de la genética: Revisión bibliográfica. *Enseñanza Cienc.* **1995**, *13*, 379–385. [[CrossRef](#)]
74. Lévêque, C.; Mounolou, J.C. *Biodiversité*; Dynamique Biologique et Conservation, Dunod: Paris, France, 2001.
75. Castro, R.G.; Motokane, M.T.; Pereira, M. O efeito da construção de uma usina hidrelétrica na biodiversidade de peixes: Uma investigação sobre frequências alélicas e fenotípicas. *Genética Na Esc.* **2018**, *13*, 39–47. [[CrossRef](#)]
76. Castro, R.G. A Construção de Argumentos no Processo de Recontextualização do Conceito de Biodiversidade. Master's Thesis, Biologia Comparada, Universidade de São Paulo, São Paulo, Brasil, 2017.
77. Diniz, E.M.; Tomazello, G.M. O tema biodiversidade em livros didáticos de ciências do ensino fundamental. *Comunicações* **2006**, *13*, 87–97. [[CrossRef](#)]
78. Goulson, D. Effects of Introduced Bees on Native Ecosystems. *Annu. Rev. Ecol. Evol. Syst.* **2003**, *34*, 1–26. [[CrossRef](#)]
79. Baldin, N.; Albuquerque, C. Cidadania ecológica. Conceções e práticas de estudantes universitários. *Forum Sociológico* **2012**, *22*. [[CrossRef](#)]
80. Cohen, E.F. *Semi-Citizenship in Democratic Politics*; Cambridge University Press: New York, NY, USA, 2009.
81. Pinheiro-Machado, R.; Freixo, A. *Brasil em Transe: Bolsonarismo, Nova Direita e Desdemocratização*; Oficina Raquel: Rio de Janeiro, Brasil, 2019.
82. Spivak, G.C. *Pode o Subalterno Falar? Tradução de Sandra Regina Goulart Almeida; Marcos Pereira Feitosa; André Pereira*; Editora da UFMG: Belo Horizonte, Brazil, 2010.
83. Freire, P. *Pedagogia da Autonomia: Saberes Necessários à Prática Educativa*; Editora Paz e terra: São Paulo, Brazil, 2014.
84. Leff, E. *Epistemologia Ambiental*, 5th ed.; Cortez: São Paulo, Brasil, 2010.
85. Valladares, L. Scientific literacy and social transformation. *Sci. Educ.* **2021**, *30*, 557–587. [[CrossRef](#)]

86. Santos, W.L.P. Scientific literacy: A Freirean perspective as a radical view of humanistic science education. *Sci. Educ.* **2009**, *93*, 361–382. [[CrossRef](#)]
87. Hooks, B. *Teaching to Transgress*; Routledge: London, UK, 2014.
88. Hodson, D. *Teaching and Learning Science: Towards a Personalized Approach*; Open University Press: Buckingham, UK, 1998.
89. Reis, P.; Tinoca, L.A. A avaliação do impacto do projeto “We Act” nas percepções dos alunos acerca das suas competências de ação sociopolítica. *Rev. Bras. De Ensino De Ciência E Tecnol.* **2018**, *11*, 214–232.
90. Agostinho, A.; Reis, P. Contributos educativos de exposições interativas on-line sobre imunidade como prática de ativismo coletivo em contexto de pandemia. *Uni-Pluriversidad* **2021**, *21*, 1–22. [[CrossRef](#)]
91. García Bermúdez, S.; Reis, P.; Vásquez Bernal, B. Facebook como herramienta para promover el activismo ambiental en las clases de ciencias. *Enseñanza De Las Cienc.* **2022**, *40*, 1–20. [[CrossRef](#)]
92. Kowasch, M.; Cruz, J.; Reis, P.; Gericke, N.; Kicker, K. Climate Youth Activism Initiatives: Motivations and Aims, and the Potential to Integrate Climate Activism into ESD and Transformative Learning. *Sustainability* **2021**, *13*, 11581. [[CrossRef](#)]

Disclaimer/Publisher’s Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.