



Argumentation among pre-service Biology teachers: conceptions, pedagogical intentionality, and impacts on argumentative quality

*Argumentação com licenciandos em Ciências Biológicas: concepções,
intencionalidade pedagógica e impactos na qualidade argumentativa*

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Abstract: Argumentative competence is associated with the ability to construct, mobilize, and refute arguments within the contexts in which individuals are situated. In this regard, the present study aimed to analyze pre-service Biology teachers' conceptions of argumentation in teaching and learning processes, as well as the impacts of pedagogical activities intended to foster the development of their argumentative quality. This qualitative study employed semi-structured interviews with undergraduate students enrolled in a Biological Sciences teacher education program at a public institution. The participants had previously engaged in an instructional intervention focused on producing a socio-about issue. Content analysis was used to organize, examine, interpret, and draw inferences from the data. The findings indicate that the development of argumentative competence requires intentional pedagogical planning and structured instructional strategies that provide students with progressively more challenging opportunities to refine their argumentative skills.

Keywords: argumentative competence, science education, socioscientific issues, arguments.

Resumo: A competência argumentativa está relacionada com a capacidade de construir, mobilizar e refutar argumentos, independentemente da área e contexto em que as pessoas estão inseridas, sendo uma habilidade importante para sustentar ideias e desenvolver a criticidade, principalmente durante a formação de novos profissionais. Diante disso, este artigo objetivou analisar as concepções dos licenciandos em Ciências Biológicas sobre a



argumentação no processo de ensino e de aprendizagem, bem como os impactos das atividades pedagógicas voltadas para o desenvolvimento da qualidade argumentativa desses licenciandos. Trata-se de uma pesquisa de abordagem qualitativa com aplicação de entrevistas semiestruturadas junto a estudantes de licenciatura do curso de Ciências Biológicas de uma instituição pública. Os licenciandos entrevistados participaram previamente de uma intervenção para a produção de argumentos sobre uma questão sociocientífica. Foi utilizada a análise de conteúdo para organizar, explorar, interpretar e fazer inferências sobre os resultados. Como resultado, tem-se que o desenvolvimento da competência argumentativa requer um planejamento pedagógico intencional e estratégias didáticas estruturadas que ofereçam aos alunos oportunidades progressivas para aprimorar suas habilidades argumentativas.

Palavras-chave: competência argumentativa, ensino de ciências, questão sociocientífica, argumentos.

Introduction

Argumentation has been recognized as a fundamental competence for promoting science education. In Charles Darwin's work *On the Origin of Species*, published in 1859, for example, the author reveals how a "long argument" can present and discuss strong evidence, demonstrating that argumentation is a vital mechanism in the construction of scientific knowledge (Jiménez-Aleixandre & Erduran, 2007). From this perspective, Jiménez-Aleixandre and Erduran (2007) argue that argumentation has two essential characteristics: the justification and support of knowledge, and the role of argumentation as a persuasive process.

Justification and support of knowledge articulate convergent lines of reasoning, theoretical conceptions, and empirical evidence to defend a claim. Darwin exemplifies this practice in his work by gathering empirical data during his expedition through Central and South America, which served as the basis for his natural selection theory. The second characteristic, on the other hand, concerns argumentation as a persuasive process aimed at convincing an audience of the claims presented. In Darwin's case, this process was particularly challenging, resulting in the publication of his work only two decades later (Jiménez-Aleixandre & Erduran, 2007).

The emergence of argumentation is grounded in the construction of rhetoric. According to Valle (2009), rhetoric fully developed after the stabilization of democracy in Athenian society. At that time, the citizens of Athens had the right to participate directly in public decisions, exercising judicial, legislative, and executive functions. In this sense, holding a political role was reserved for those who mastered communication, reasoning, and the proper production of arguments.

For Perelman and Olbrechts-Tyteca (2005), the purpose of argumentation is to obtain the audience's agreement with the propositions presented by a speaker. To

support this premise, it is important to conduct an effective argumentative process that is well suited to gaining public acceptance. In other words, the proposal defended by the speaker must be accepted by the participants or, at least, must motivate the listener to agree with or accept what the speaker has said. Thus, there is an interaction between the speaker and the audience, which is carried out through language.

Within the scope of these theoretical discussions, argumentation in science education considers the Toulmin Argument Pattern (TAP), proposed by Stephen Toulmin in 1958, as a consolidated framework in this field. According to Toulmin (2003), an argument can be understood as an organism composed of anatomical dimensions, organized into a more elaborate structure that enables it to support or contest information.

In the TAP model, the conclusion or claim (C) and the data (D) that support it are presented. The data leads to a conclusion through warrants (W). This scheme, however, became more complex by incorporating other components: modal qualifiers (Q), which indicate the degree of strength of the conclusion; rebuttal conditions (R), which indicate circumstances capable of weakening or invalidating it; and backing (B), which provides support for the warrants, expanding the robustness of the argument (Toulmin, 2003).

On the other hand, it is also possible to recognize this model's limitations. Acknowledging them, Erduran et al. (2004) adapted the TAP for methodological purposes in their investigations. The authors explain that using Toulmin's tool in their previous studies made valuable contributions that enabled them to improve it. However, it did not yield considerable insights into the quality of argumentative discourse produced during a classroom intervention. To analyze arguments in terms of their quality, the authors developed an analytical framework that lists five levels of argumentation for assessing argument quality (Erduran et al., 2004).

According to Erduran et al. (2004), the TAP structures an argument by relating a claim to the data that supports it, the warrants that connect the data to a claim, the backing that strengthens the warrant, and, finally, the rebuttals that indicate the elements under which the claims may not be true. Toulmin (2003) also considers qualifiers, which refer to a higher degree of reliability attributed to the conclusions. However, the use of the TAP to analyze verbal arguments has presented difficulties, the greatest of which is distinguishing what constitutes a claim, data, a warrant, or backing.

These perspectives highlight the relevance of structural and analytical frameworks for understanding argumentation in science education, particularly

regarding the organization of arguments and the identification of their components. However, by privileging the structure and internal organization of arguments, they may not sufficiently address the discursive, interactional, and contextual dimensions of argumentation in real teaching and learning situations.

In this context, it is important to consider contributions from linguistics, which expand our understanding of argumentation by looking at interaction and dialogue. The dialogical model of argumentation, developed by Christian Plantin, focuses on interaction as the primary element in this process. It has a tripolar structure: question, proponent, and opponent. The question is the central issue or problem that shapes the argument and evaluates the arguments presented. The proponent is the participant who shares their view on this issue. The opponent challenges and contests the proponent's argument (Grácio, 2008).

The study by Pistori and Banks-Leite (2010) examines argumentation through Bakhtin's theory, which supports a complex approach to analyzing arguments. This approach goes beyond a purely structural view and considers the dialogue and value aspects of communication. Goulart (2009, p. 17) points out that the dialogical principle is fundamental to understanding language. It is essential to all discourse. Dialogism, therefore, shapes the meaning of discourse and connects language to cultural life.

Amossy (2008) sees argumentation as an intrinsic part of discourse analysis. She suggests that argumentative processes should go beyond just securing agreement with a premise. They should also include efforts to influence others, highlighting persuasive elements. The author explains the difference between argumentative intention and argumentative dimension. The first defines discourse as a means of persuading an audience of a specific thesis. The argumentative dimension, on the other hand, relates to discourse that aims to guide listeners without a clear intent to persuade.

The approaches discussed show that we can understand argumentation from various theoretical angles and interests. While frameworks like Toulmin's, often used in Science Education research, focus on analyzing argument structures and identifying their parts, ideas from linguistics allow for fresh insights. They highlight the interactive and conversational aspects of argumentation.

In the classroom, argumentation helps us see how teachers, students, teaching resources, and the knowledge being built interact. These situations can boost active participation in the teaching and learning of Science-related topics (Sasseron, 2020). Therefore, it's crucial to view argumentation as a dialogue. This view supports the educator's dialogical role and aids knowledge construction.

Santos and Mortimer (2009) stress the importance of the teacher's dialogical role in their classes. Teachers should create opportunities for students to take part in shaping their knowledge. This approach should value the diverse experiences and strengths present in the school environment. Such an attitude will help enhance the understanding of scientific and technological knowledge, encouraging the interpretation of Science and Technology concepts related to their negative effects on living beings on the planet.

Argumentation goes beyond defending specific ideas or positions. It involves questioning different opinions, critically assessing information, taking an evidence-based approach toward conflicting views, understanding various perspectives, presenting alternative arguments, and modifying one's own views or those of others when needed. These skills are vital in education and should be taught as core elements. Outside of academics, these abilities are essential for peaceful social interactions (García-Barrera, 2015).

In this context, Rapanta et al. (2013) describe argumentative competence as the ability to create, assess, and challenge arguments during interactions and dialogues within one's community. Developing this competence demonstrates how specific skills can be applied in practice.

Ruiz et al. (2013) highlight that teaching argumentation relies on various factors, particularly focusing on conceptual elements. The significance of the conceptual aspect lies in strengthening argumentation as a social and dialogic process. This perspective enables teachers to evaluate students' learning in the classroom by examining the intent behind these processes, viewing the ability to argue as an effort to convince and persuade.

In this context, to develop argumentation, it is necessary to consider the practices involved in building knowledge. The methods and approaches should be practical. It is also important to discuss the tools linked to generating arguments (Jiménez-Aleixandre & Brocos, 2015).

The use of Socioscientific Issues (SSIs) in teaching and learning has been widely explored to develop argumentation. According to Batinga and Barbosa (2021), allowing discussions about an SSI in schools stimulates the growth of scientific thinking and language. This leads to a deeper understanding of scientific knowledge. Therefore, the link between SSI and argumentation becomes stronger.

The study by Vale et al. (2023), which examined an SSI related to pesticide use in crops, highlights the importance of this tool. The results showed that the SSI helped develop argumentation in the participants' texts. It was possible to see argumentative movements aimed at negotiating ideas. These processes involve

thinking and providing reasons in forming arguments and counterarguments about the discussed SSI.

The discussions presented emphasize the significance of argumentation as a key practice in developing critical citizens. They also highlight the role of teaching strategies in enhancing argumentative skills. Given this context, this research aims to answer the following question: What do students in a Biological Sciences Teacher Degree program think about developing argumentation through intentional teaching strategies, and how do the proposed activities affect the quality of their arguments?

This article aims to analyze the views of pre-service Biological Sciences teachers on argumentation within the teaching and learning process. It will also examine the effects of teaching activities aimed at improving the argumentative quality of these pre-service teachers.

This study draws on frameworks from Science Education that view argumentation as both an epistemic practice and a teaching practice. It focuses on teaching and learning situations influenced by socio-scientific issues, using approaches that emphasize dialogue (Sasseron, 2020; Santos & Mortimer, 2009). The theoretical foundations guided the development of analytical categories (Bardin, 2011) based on empirical data. This analysis considered pre-service teachers' views and the impact of teaching strategies on argumentative quality.

Methodological Procedures

This study is part of the first author's doctoral research, involving pre-service teachers in Biological Sciences at a public university in Northeastern Brazil. To ensure a connection between the methods and the research goals, we used a qualitative approach. As Flick (2009) explains, qualitative studies rely on ongoing dialogue between the researcher and the field of evidence collection, which is key to producing knowledge.

The data analyzed in this article were collected through semi-structured interviews with six students who had previously participated in a pedagogical intervention. This intervention used a Case Study (CS) about an SSI on animal testing. It aimed to encourage the production of written arguments in both individual and group activities.

The interviews aimed to present students with an initial analysis of the arguments they created during the intervention and to discuss the development of argumentation in their learning process. We also examined the methods and

strategies employed during the intervention. The interviews were recorded and transcribed verbatim to maintain accuracy, then analyzed and discussed.

According to Gaskell (2002), when conducting individual or group interviews, it is important to consider two factors: defining the questions for the topic guide and selecting the right participants. The topic guide is a crucial part of the research. It should be developed thoughtfully, grounded in theoretical frameworks, an understanding of the field of study, and discussions with knowledgeable individuals.

We created an interview script with four main areas to explore with the students: 1) initial perceptions of the formative process; 2) ideas about argumentation; 3) connections between argumentation and teacher education; and 4) teaching strategies used in the intervention. The themes in each area connect to meet the goal of gathering useful data from the interviews.

We submitted the interview script for peer review by researchers experienced with this type of data collection tool. This review helps ensure that the questions are suitable for meeting the study's objectives and that there are no unclear sections. The specialists signed the Informed Consent Form (ICF) to follow ethical research guidelines.

We presented the research to the Research Ethics Committee (REC) for Human Subjects at the Federal University of Sergipe (UFS). It received approval on March 6, 2023, identified by opinion number 5,926,009. All information from the intervention is confidential, so we will not disclose participants' names. To protect their identities, we used fictitious names for everyone involved. This approach follows the ethical standards outlined in Resolutions No. 466/12 (Brazil, 2012) and No. 510/16 (Brazil, 2016). The names we chose were Rose, Ruana, Dani, Leo, Alícia, and Saulo. It is important to note that all six pre-service teachers signed the ICF and the Authorization Form for the Use of Testimony.

The researchers transcribed the interviews using *Google Colaboratory* (Colab), an interface connected to Google and accessed via an extension. According to Silva (2024), this digital tool enables transcription of audio and video content. It also aids in analyzing vocabulary and grammar. Even though Colab helped organize the data, the researchers closely monitored every step, performing reviews and corrections to guarantee the accuracy and integrity of the transcribed information.

For the interview analysis, we employed Bardin's (2011) Content Analysis (CA). This method is described as "a set of techniques for analyzing communications, using systematic and objective procedures for describing the content of messages" (Bardin, 2011, p. 38). After conducting the interviews, we transcribed the data and carefully reviewed it to organize the relevant aspects for

analysis. We followed the stages of CA: pre-analysis, exploration of the material, treatment of results, inference, and interpretation.

The pre-analysis stage involves organizing the findings that form the research corpus. We followed Bardin's (2011) guidelines throughout the process. These guidelines include exhaustiveness, representativeness, homogeneity, and relevance.

The exploration phase involves a deeper analysis of the data. Its goal is to create the Recording Units (RU) and identify the Context Units (CU). To develop the RU, we focused on the meaning of the themes that emerged from the data. The CU consists of fragments that explain the RU (Bardin, 2011). We highlighted various themes that frequently appeared in the interviewees' responses, which formed the RU and were supported by excerpts demonstrating them. Next, we moved on to the treatment of results stage, characterized by inference and data interpretation (Bardin, 2011).

Results and Discussion

After conducting the interviews and transcribing the data, we carefully read the material and selected excerpts from participants' statements to form the Context Units (CUs). Next, we organized the selected excerpts into Recording Units (RU) and into categories created afterward. The first category relates to views on argumentation in Biological Sciences teaching. The second focuses on planning and purpose in teaching argumentation, while the third looks at how teaching methods affect the quality of arguments.

Views on Argumentation in Biological Sciences Teaching

Category one, which focuses on views of argumentation in Biological Sciences teaching (Table 1), discusses the various aspects of argumentative practice that the pre-service teachers mentioned during the interviews.

Table 1

Description of the recording units and context units of the category “conceptions of argumentation in Biological Sciences teaching” among pre-service teachers

Category	Recording Units (RU)	ContextUnits (CU)
Conceptions of argumentation in Biological Sciences teaching	Argumentation as a communicative and expressive process	<i>“I think it is a communication process that aims to develop ideas about a given topic, as well as justifications to defend one’s opinion. It is necessary to articulate ideas and, above all, arguments in order to demonstrate depth in the discussion” (Ruana).</i>
	Argumentation as a process of knowledge construction	<i>“The teacher should not reproduce a discourse that knowledge is unaltered. In fact, it is an entire construction. So, you have to learn how to argue in order to make students understand that concept, that content, that subject” (Dani).</i>
	Argumentation for developing critical thinking and autonomy	<i>“From my perspective, a person who knows how to argue has a greater ability to convince people. And this has a lot to do with the teacher’s role in discussing knowledge, and when the teacher argues well, the class flows better and students learn better, generating autonomy in students to speak in class. At least that is how it is for me; a teacher who speaks and expresses themselves well captures the student’s attention” (Alicia).</i>
	Argumentation as a social practice and as a means of promoting relationships	<i>“I think argumentation is a social practice that involves everything around us. It is like, let me think of the word... a criterion, something like that, for socializing with other people. It is necessary to have good arguments to defend our position, for example” (Saulo).</i>

We found that the participants give various meanings to argumentation. They emphasize its role in expressing ideas and in promoting critical and reflective learning. This insight underscores the importance of connecting theoretical frameworks to the daily experiences of pre-service teachers.

In the first RU, understanding argumentation as a means of communicating and expressing ideas is important. It stresses the need for clear, well-articulated thinking among people. This view shows how essential communication is in building and sharing scientific knowledge. Student Dani emphasizes this point:

I believe argumentation is an important skill for everyone, no matter their field. We need to build our ability to speak and express ourselves clearly to an audience with connected and coherent statements. I think argumentation ties into this. It involves communication and defending positions with solid justifications, something like that (Dani).

The student points out key parts of the argumentative process, including skills for speaking in front of an audience, the role of communication, and the defense of positions grounded in justification. Santos et al. (2001) argue that dialogical interaction is crucial for developing argumentation because it pushes students to

create and maintain their ideas through clear justifications. In this context, analyzing discourse in learning environments is essential since it aims to improve students' argumentative skills.

Following this idea, Grácio (2008) examines argumentation through the dialogical model suggested by Plantin. He claims that argumentative processes should be interactive and challenging. He also emphasizes that argumentation is inherently interactive and moves away from a one-sided view. He proposes a tripolar structure that includes a question, a proponent, and an opponent in discussions.

From this angle, Jiménez-Aleixandre (2010) suggests that arguing is the ability to assess claims based on evidence. This means recognizing conclusions and supporting them with justifications based on scientific knowledge. According to this view, argumentation is a skill that evaluates knowledge, shaped by each person's experiences and observations and influenced by the ideas presented by experts at different times.

The accounts in the second RU suggest that argumentation is seen as a vital tool for building knowledge. The participants interviewed value interactive processes in the classroom. They emphasize that teachers need to argue effectively to help their students learn. Additionally, it is important to stress that developing strong justifications is crucial for solidifying knowledge in their area of practice, as Rose and Leo illustrate in their statements.

When someone builds a more critical argument, they move away from common sense. This gives them a foundation to stand on. It also helps validate their views on issues they agree or disagree with. This approach creates knowledge in a more meaningful and thoughtful way (Rose).

When I think about teachers, it's important that they know how to argue effectively. This relates directly to the quality of their classes. It can even encourage students to participate and argue, which improves their knowledge and aids their learning. Therefore, teachers need to communicate well and present strong arguments about the subjects they teach (Leo).

According to Sasseron and Carvalho (2011), argument construction occurs dynamically in the classroom. Debates, conversations, expressing ideas clearly, and reflecting on results from tasks or other knowledge sources are ways knowledge is shared and evaluated in school. These exchanges help students recognize connections between information and logically organize their statements. This leads to the creation of scientifically grounded arguments.

Building and defending scientific explanations are complex practices. They highlight the need to assess initial and ongoing teacher training. It is crucial to consider whether teacher education programs prepare professionals to view

argumentation as a key part of Science teaching. They should encourage a classroom environment that promotes scientific literacy (Freire, 2014).

Goulart (2009), drawing on Bakhtin's ideas on discursive interactions, points out that classroom dialogue should help identify meaning tensions arising from different interpretations students have of the teacher's statements, their classmates, and the authors used in learning. It also involves the meanings the teacher constructs from the students' statements.

The third RU shows that argumentation encourages students' critical thinking and autonomy. Interviews reveal that the teacher's ability to argue effectively is important. This skill boosts students' willingness to engage in discussions and makes classes more dynamic. The following excerpts illustrate this:

The teacher must have a certain command of the subject they will be discussing with students or others. It is important to know how to argue to direct ideas better and mediate situations, helping develop students' leadership and critical thinking (Alícia).

As a future teacher, it is important for us to learn how to develop arguments to justify or counter certain ideas. This also shows a stronger grasp of knowledge and encourages students to do the same and become more independent, especially in the classroom, where students increasingly ask new questions (Dani).

The mobilization of discussions in a socioscientific scenario, which includes different fields of study, is one way to promote the development of argumentation. These situations help improve critical thinking and decision-making. A key part of this debate is the controversy that arises from the clash of different views and opposing arguments (Barbosa & Batinga, 2021).

In the study by Conrado et al. (2015), which focused on the use of SSI related to environmental issues, the findings showed that combining argumentation with SSI through CS can expand learning opportunities and knowledge building, both in and outside the classroom. It also encourages students to think critically and make decisions about social issues.

In the final RU, argumentative activity is seen as an essential part of daily interactions and relationships; it relates to living together in society. Saulo's statement (Table 1) suggests that argumentation is more than a skill for academics; it is crucial for social interaction.

Argumentation as a social practice also aims to persuade the audience of the validity of a particular viewpoint. Each argument combines evidence and theories, serving as a social tool to support ideas. As knowledge evolves, new information can lead to different interpretations and changes in theories. This dynamism gives scientific models their temporary nature (Jiménez-Aleixandre, 2010).

Therefore, analyzing this category provides a complete view of students' ideas. It shows that argumentation in the context of teaching Biological Sciences is a complex process that brings together communication, knowledge, critical thinking, and social elements.

Planning and Intentionality in Argumentation Teaching

Argumentative processes in Biological Sciences teaching do not occur spontaneously. Teachers must demonstrate intentionality and strategic planning for these practices to be developed effectively. The second category addresses planning and intentionality in the teaching of argumentation (Table 2).

Table 2

Category	Recording Units (RU)	ContextUnits (CU)
Planning and intentionality in the teaching of argumentation	Environments and contexts that stimulate argumentation	<i>"In one course, the teacher gave us a topic and asked one side to be against it and the other in favor, and through that we developed something like a jury. For example, with a topic such as deforestation, some would be against it and others in favor. Still, we know that those who are against it have a greater number of arguments, while those in favor end up having to look for things far beyond their imagination, and this ends up greatly awakening students' interest. I think it is very important" (Saulo).</i>
	Argumentation teaching	<i>"It would be interesting to have a course that worked only with this aspect of argumentation... to actually teach us how to argue, to discuss controversial topics. SSI is the name, right? Because, for example, I did not know what SSI was, and I thought it was an excellent way to develop argumentation, because we have to take a position on the controversial topic" (Leo).</i>

The students' accounts show that using planned methods and specific activities significantly helps build argumentative skills. This approach allows pre-service teachers to express their knowledge in a clear and organized way.

According to the study by Silva and Silva (2025), when we think about the school setting, evaluating knowledge claims, or statements about scientific knowledge, should include defending and revising one's own views while also considering differing perspectives. We see that guided teaching practices promote modeling and the use of clear criteria, with argumentation fostering thoughtful criticism of knowledge claims.

The first RU identified in this area highlights the need for spaces and strategies that support argument construction. The interviewees report that various methods and approaches, such as case studies, debates, mock trials, and conversation circles, are crucial for creating environments that encourage the formation and defense of ideas.

Additionally, the classroom environment and the teacher's role as a mediator are key factors in motivating students to argue. These points are clearly reflected in the comments by Dani, Saulo, and Alícia:

In my experience, I believe so. I took part in the extension event for the Cultural Perspectives course. My goal, like that of my classmates, was to explore the issue of racial prejudice in relation to hair. We looked at how racism impacts the self-perception of Black individuals and connected this to biology. To do this, we needed to understand scientific racism and discuss it with others. We built arguments around it (Dani).

The courses that allow us to develop arguments the most are in education. We are encouraged through different strategies to engage in dialogue and defend our opinions. For instance, in education courses, we often discuss situations in schools. Whether we want to or not, we find ourselves developing arguments to support our views on those situations (Saulo).

For teachers to help students develop argumentative skills, they must also know how to argue. In addition to creating activities aimed at this goal, teachers need to understand how to argue for themselves. This helps encourage students to do the same. We can learn this through classes that promote open discussions and more debates (Alícia).

The study by Ramírez et al. (2013), conducted with university students, supports our research findings. It suggests that students' ability to produce and evaluate arguments is closely linked to the characteristics of the discursive situation they face. That study used critical debate as a strategy. This method encouraged ongoing reflection on argumentative discourse and required students to construct, identify, and critically assess arguments.

Another method explored to encourage argument development is investigative activities. These activities actively involve participants in building knowledge while examining aspects of Science as part of the curriculum. Inquiry-based teaching also helps improve argumentative skills, which are vital in school and everyday life (Geraldi & Scarpa, 2017).

The work by Reis et al. (2020) examined the use of the educational game "World of Parasites" in Biology teaching to see how argumentation was formed. This educational resource successfully promoted interactions between students and the teacher, and among students themselves, creating a rich environment for developing argumentation. However, only a few groups engaged in in-depth discussions, which hindered the development of strong arguments. Moving from discussion to solid

argumentation requires skills such as connecting data, interpreting texts, and evaluating classmates' statements.

Freire (2014), in her dissertation, examined the differences between argumentation and explanation in Ecology teaching through a didactic sequence implemented with teachers. Her findings showed that constructing explanations and arguments with scientific rigor did not happen naturally, even among educators. The instructional environment was crucial for enriching and expanding the complexity of the participants' discourse.

The second RU discusses the interviewed students' view of teaching argumentation as an important part of their learning process. The pre-service teachers stress that this skill must be built intentionally throughout their undergraduate education, through specialized courses or by incorporating it across various fields of study.

This approach would help future teachers understand the theoretical foundations of argumentation and apply them in their teaching practices, as Rose and Ruana point out:

If there were a course that focused on this, it would be perfect. Then you would have a complete focus on it. However, not having the course itself is not an issue. It could be included in other courses or in all of them. I think there is room for discussion about this in the Didactics course. In Didactics, we learn how to manage the classroom and how to transfer content (Rose).

Maybe a course that covers argumentation would be interesting, or we could include it in one that already exists. It may be aimed at higher education, but I believe this practice should start in Basic Education. When we reach higher education, many professors expect students to already know about argumentation and to understand the basics of science (Ruana).

It is important to provide university students with education focused on improving their argumentative skills. This investment can positively affect teaching and learning, encouraging reflective practice and the independent construction of knowledge (Ramírez et al., 2013). To achieve this, we must create environments that support the development of high-quality arguments and carefully plan teaching methods.

In the context of this study involving students in a Biological Sciences Teacher Degree program, it's helpful to discuss the research by Ibraim and Justi (2017). They suggest that the implicit teaching of argumentation during initial teacher education involves placing students in situations that promote argumentative practice, such as investigative scenarios or discussions about SSI, without direct instruction on what arguments are or how to engage in argumentative practice in the classroom. From

this view, understanding argumentation and its role in teaching is expected to come from real experiences.

For students with little experience in this area, the first step is exposure to argumentative expressions. Research by Hung et al. (2017) found that during argumentation instruction, arguments from different groups competed against each other. This encouraged students to support or challenge their classmates' positions based on what they had learned. This exchange of ideas helped students recognize differences in their arguments, thereby increasing their involvement and participation in discussions.

From the discussions in this subsection, it is clear that planning how to teach argumentation goes beyond simply applying activities from time to time. It requires creating ongoing opportunities for developing argumentative skills. This approach supports learning that not only enhances scientific communication but also boosts students' autonomy and critical thinking. The next subsection will further explore the impact of strategies for developing arguments.

Impacts of Teaching Strategies on Argumentative Quality

Students' argumentative quality develops through interactions, reflections, and experiences during their learning. This section shows how the teaching strategies used in this study may affect the construction and improvement of arguments among pre-service teachers in Biological Sciences. It considers the variety of claims and the development of justifications throughout the activities. Table 3 presents the recording units generated from this discussion.

Table 3

Description of the recording units and context units of the category “impacts of strategies on argumentative quality”

Category	Recording Units (RU)	ContextUnits (CU)
Impacts of teaching strategies on argumentative quality	Plurality of opinions and group discussions	<i>“I liked it; it was nice, very interesting, and very productive. The debates in which we gathered, gave our opinions, were very interesting. And the production of the posters was also good. It brought more information about the experiments that were carried out, in addition to the discussions with classmates, which help construct ideas to strengthen our individual opinion” (Alícia).</i>
	Evolution of arguments during the process	<i>“So, I think it was exactly a construction. After reading what I had initially written in the last classes, I was like, my God, this is completely different. Not completely different, but it was poorly elaborated. At the end of the process, all the discussions helped me [sic] improve a lot, because I also learned many things in the classes, basic knowledge that I did not have” (Saulo).</i>

In the first RU, we looked at how multiple ideas and group discussions shape argumentative thinking. Sharing experiences among the pre-service teachers helps them see different perspectives. This encourages them to create rebuttals and broaden their justifications. Additionally, using methods such as case studies, debates, SSI, and station rotation helped students feel more confident when defending their views.

Dani, Alícia, and Ruana support this idea, as shown in the following excerpts:

Even though I had formed an opinion with some arguments in the first class, I believe that this case study on a controversial topic and the station activities helped me understand and better express the alternatives to animal testing. Before, I had a limited idea about it. I think the actions gave me more clarity (Dani).

The case study on the socioscientific issue was very helpful. It encouraged everyone in our class to engage, which is rare. Everyone was able to argue and form their opinions. At the beginning of the case study, students expressed various views. Some said they were in favor, while others were against it. Thanks to this case study, we were able to form our own opinions on the topic (Alícia).

This case study method really encourages investigation and critical thinking from the students. I think it is a good approach for schools because it develops students' critical thinking, research skills, and reasoning. This supports the building of arguments (Ruana).

Idalino and Guimarães (2023) highlight the role of SSI in teaching and learning. They point out that SSI can improve students' argumentative skills, encourage more thoughtful decision-making, and enhance their critical thinking. These qualities are crucial in Science education. For this approach to work well, it is

essential to invest in both initial and ongoing teacher training. Teachers need the knowledge to incorporate these ideas into their teaching practices.

The study by Almeida and Guimarães (2019) supports the view that including SSI with an argumentative, ethical, and moral focus in Basic Education requires that teachers have access to courses that encourage reflection on the importance of critically and thoughtfully discussing current bioethical issues during their training.

The second RU in this category deals with how arguments develop throughout the teaching and learning process. Reports show that as students engage with various information sources, participate in reflective discussions with peers, and critically evaluate their own reasoning, their arguments become more organized and well-supported. This development occurs both in the logical arrangement of their ideas and in the presentation of stronger evidence to back up their positions, as noted by the participant Leo:

I really liked the group activity and the discussions at the end of the moment when we wrote the arguments, because this makes us come into contact with other views and, whether we want to or not, improves our ideas. In my final argument, I was able to develop it with greater command (Leo).

Among the changes observed in this process, it is important to note that the development of argumentative discourse in the classroom relies on the interaction among students, teachers, knowledge, and context, rather than just the direct relationship between student and teacher. Additionally, group work in smaller teams and cross-subject collaboration showed promise for improving and expanding argumentative skills in teaching (Ruiz et al., 2013).

Barbosa and Batinga (2021), while discussing the SSI “food supplementation,” found that this approach facilitated the exchange of ideas and diverse viewpoints, as well as the development of justifications. In the discussions among students, their peers, and the teacher, it was possible to identify argumentative situations through the presence of arguments, counterarguments, and responses. These elements create a framework for examining the progression of argumentation in the classroom.

The study by Erduran et al. (2004) shows that improvements in the quality and complexity of arguments stem from a mix of teaching methods, the use of organizing tools, and active engagement by the teacher. The authors stress that argumentation does not develop naturally; students need explicit instruction and well-designed strategies to learn to argue.

Understanding this aspect reveals that argumentation is not a fixed process. It is dynamic, ongoing, and progressive, enhanced through teaching methods specifically designed to encourage interaction and critical thinking. Practices that

encourage the clash of viewpoints and the revision of justifications have proven effective in boosting the argumentative skills of future teachers.

Final Considerations

This research aimed to understand how students in a Biological Sciences Teacher Degree program view the development of argumentation through specific teaching strategies. It also looked at how class activities affect the quality of their arguments. This was done by analyzing the results of semi-structured interviews with six pre-service teachers at a Brazilian public university.

The data led to the creation of three main analytical categories. The first category, "conceptions of argumentation in Biological Sciences teaching," showed that participants had different views on the topic. Many associated it mainly with the formal structure of debates, but also considered communication, autonomy, and critical thinking.

The second category, "planning and intentionality in the teaching of argumentation," revealed that the pre-service teachers recognized the need for well-structured teaching strategies to support their growth in argumentation. They noted that the tasks improved their learning and provided tools to advance their arguments and deepen discussions.

The third category, "impacts of teaching strategies on argumentative quality," indicated that participants noticed significant improvements in their argumentative skills. Many expressed that throughout the process, they gained more confidence in crafting arguments and justifying their views. This progress highlights the importance of teaching practices that consistently encourage argumentation and create learning environments where students can develop and refine this skill in a structured, gradual way.

In conclusion, the findings suggest that developing argumentative skills requires careful instructional planning and structured strategies that provide students with ongoing opportunities to improve their abilities.

Although the data emphasize the importance of learning situations that foster argument generation, we need to question the idea that simply developing argumentation can explain learning processes. Creating more structured, high-quality, and convincing arguments doesn't always lead to a deeper understanding of concepts. Arguments may be coherent and persuasive, but they might be based on weak theoretical foundations or narrow interpretations of scientific knowledge.

In this context, argumentation should be seen as a practice that requires connection to a critical understanding of scientific content, supportive teacher guidance, and learning environments that encourage not just the defense of ideas but also their questioning, revision, and reconstruction.

The findings of this study could pave the way for future research aimed at expanding the discussions on this topic. One potential research idea is to broaden the study to include different student groups or educational settings. This would help us analyze how differences in participant backgrounds and the methods used affect the development of argumentation. Additionally, future studies could examine how targeted training for teachers who lead argumentative activities influences students' understanding.

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