





Interdisciplinarity and Contextualization in the Higher Education Chemistry Course: An Investigation Enveloped in the Bias of the Animal Issue

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Abstract

In this work, we start from the assumption that dealing with the animal issue in education has become increasingly relevant. This statement gains strength in the examination of official documents for education in its various modalities, since they seek to include themes that stimulate ethical, solidary and citizen thinking beyond the compartmentalized. Thus, we take as essential the act of “greening up” the disciplines taking into account what is contextual to them. With this in mind, we propose to carry out a survey in order to understand how Chemistry professors see contextualization and interdisciplinarity, which includes aspects of the animal issue, in their disciplines. For that, we defined a cut that covers public institutions of higher education in Minas Gerais, building an investigation through questionnaires previously submitted to the pilot experience and, later, to the content analysis. As part of the results, we bring the categories “The animal issue and its crossing” and “Pedagogical practices in the classroom”. From the treatment of the data, we discussed the hypotheses raised and we found that there are understandings both contrary to the insertion of the animal theme due to a scarce relationship between it and the course, and of not only being able to work in the classroom, but already being present, with the interdisciplinarity being a means for this inclusion.

Keywords: animal issue, interdisciplinarity, Teaching of Chemistry

A Interdisciplinaridade e a Contextualização no Curso Superior de Química: Uma Investigação Atenta ao Viés da Questão Animal

Resumo

Partimos, nesse trabalho, do pressuposto de que tratar a questão animal na educação tem se tornado cada vez mais pertinente. Tal afirmação ganha força no exame de documentos oficiais para a educação em suas diversas modalidades, uma vez que buscam a inclusão de temas que estimulem o pensar ético, solidário e cidadão para além do compartimentado. Assim, tomamos como imprescindível o ato de “ecologizar” as disciplinas levando em conta o que lhes é contextual. Com isso em mente, propomos realizar um levantamento em busca de compreender como professores de cursos de Química enxergam a contextualização e a interdisciplinaridade, o que inclui vertentes da questão animal em suas disciplinas. Para tanto, definimos um recorte que abranja instituições mineiras públicas de educação superior, construindo uma investigação por meio de questionários previamente submetidos à experiência-piloto e, posteriormente, à análise de conteúdo. Como parte dos resultados, trazemos as categorias “A questão animal e seu atravessamento” e “Práticas pedagógicas em sala de aula”. A partir do tratamento dos dados, discutimos as hipóteses levantadas e constatamos haver entendimentos tanto contrários à inserção da temática animal devido a uma escassa relação entre esta e o curso, quanto de não apenas ser passível de se trabalhar em sala de aula, mas já estar presente, sendo a interdisciplinaridade um meio para essa inclusão.

Palavras-chave: questão animal, interdisciplinaridade, Ensino de Química

La Interdisciplinariedad y la Contextualización en el Curso Superior de Química: Una Investigación Atenta al Sesgo de la Cuestión Animal

Resumen

Partimos, en este trabajo, de la suposición de que tratar la cuestión animal en la educación ha cobrado cada vez mayor relevancia. Esta afirmación gana fuerza en el examen de los documentos oficiales para la educación en sus diversas modalidades, pues se observa que buscan incluir temáticas que estimulen el pensamiento ético, solidario y ciudadano más allá de lo compartimentado. Así, tomamos como esencial el acto de “ecologizar” las disciplinas teniendo en cuenta lo que les es contextual. Con esto en mente, realizamos una encuesta para comprender cómo los profesores de Química ven la contextualización y la interdisciplinariedad, lo que incluye aspectos de la cuestión animal en sus disciplinas. Para eso, definimos un corte que abarca las instituciones públicas de educación superior de Minas Gerais, construyendo una investigación mediante cuestionarios previamente sometidos a la experiencia piloto y, posteriormente, al análisis de contenido. Como parte de los resultados, traemos las categorías “La cuestión animal y su cruce” y “Prácticas pedagógicas en las aulas de clase”. A partir del tratamiento de los datos, discutimos las hipótesis planteadas y encontramos que existen comprensiones tanto contrarias a la inserción del tema animal, debido a una escasa relación entre este y el curso; como de no sólo poder ser trabajado en el aula, sino de ya estar presente, siendo la interdisciplinariedad un medio para esa inclusión.

Palabras clave: cuestión animal, interdisciplinariedad, Enseñanza de la Química

The Animal Issue and the Teaching of Chemistry

In teaching and research in education, addressing the animal issue — namely, the perspective through which the non-human animal is considered based on its sentience and intrinsic value — has become increasingly complex and relevant. Although discussions about the well-being of these animals can be traced back to Pythagoras (570–495 BC), a renowned vegetarian of his time, technological advancements in recent years, including the growing ease of access to information, have largely contributed to the popularization of the subject.

In vogue, consideration for animals has extended beyond pets, and permeates various formal and informal contexts. In schools, there are already initiatives such as the “Segunda Sem Carne” (Meat-Free Monday)¹ campaign, supported by the Brazilian Vegetarian Society (SVB) and implemented by the state and municipality of São Paulo in school networks. We can also highlight the example of Escola Nativa, the first school in Brazil to adopt non-exploitation of animals as its guiding principle. Considering educational institutions as spaces for debates and ideological disputes, the discussions surrounding this topic are gaining momentum, further justifying the natural sciences’ pursuit to fulfill their role in this discourse.

¹ The campaign proposes, during one day of the week, the substitution of animal-based products with plant-based ones during meals. It aims at the discovery of new flavors and can serve as an incentive for long-term adoption of the practice.

However, there is a noticeable lack of literature that addresses the teaching of science in relation to the animal issue, both in basic and higher education (Fernandes & Flôr, 2020; Fernandes et al., 2021). Based on reviews woven around this theme, it is evident that there is silence regarding the integration of the animal issue in the teaching of Chemistry at the higher or technical education levels. Despite animals being present in these environments in various ways and there being a recognized need to critically address topics directly related to them (particularly food and environmental issues), no connections are made with the animal issue. In basic science education, when works approach animals as beings with rights and go beyond an anthropocentric view, the majority still adheres to speciesist ideologies, indicating that there is still a long way to go in search of a new perception within the field.

As a foundation of the animal bias, when understanding the search for guiding documents to create a new model of higher education, we can conjecture that the Brazilian university needs to be rethought and redefined to deal with the new human being as an instrument of action. According to Japiassu (2006), the university has changed over the centuries in relation to clerical and bourgeois discourses, but it is still complicit with the dominant order in the sense that it continues to transmit somewhat aristocratic and culturally and socially incomplete knowledge. It is in this sense that the role of the institution remains marginalized, and it is necessary to rethink its mission as an articulator between different forms of knowledge.

As an example, the National Curriculum Guidelines for Chemistry Courses consider trends that aim for a more holistic education, which includes reflections on character, ethics, solidarity, responsibility, and citizenship within the curriculum. Thus, there is a call for expanding the range of possibilities through the institution's pedagogical project, which must necessarily be based on concepts of matter and interdisciplinarity (Parecer CNE/CES 1.303/2001, 2001, p. 2). By understanding its social and humanistic commitment, the overall structure of the course should be defined under the light of minimizing the compartmentalization of knowledge and seeking integration between Chemistry and related fields (Parecer CNE/CES 1.303/2001, 2001). In this way, we can consider interdisciplinarity and contextualization possible, rejecting fragmented, framed, and departmentalized teaching, where disciplines and instructors are unaware of each other.

From then on, the benefits obtained go beyond mere exemplification and making the subject interesting, as it can facilitate learning, develop values for the formation of critically-thinking citizens, and shift perspective towards reality and dialogicity (Wartha & Faljoni-Alário, 2005). According to Wartha et al. (2013), by contextualizing, we construct meanings that are not neutral, and by explicitly addressing everyday life and societal contexts, we incorporate values. This helps build an understanding of social and cultural problems and facilitates the processes of discovery. In short, it leads students to understand the relevance and apply knowledge to comprehend the facts, trends, phenomena, and processes that surround them (Wartha & Faljoni-Alário, 2005, pp. 43–44). To achieve this, topics such as social, ethical, dietary, environmental, economic, labor-related, everyday, leisure, and health issues are included in the curriculum.

Incorporating animal-related issues in the classroom aligns with the purpose of opening up disciplines and expanding knowledge beyond compartmentalization. Interdisciplinarity emerges as a response to the challenge of comprehensiveness and the emergence of multidimensional problems, requiring us to develop knowledge through the capacity to contextualize and encompass (Morin, 2017). The study of nature, for example, has the potential to break away from reductionism and the simplistic, carrying within it the need to surpass unitary systems: ecology, which focuses on the study of ecosystems, draws upon multiple physical disciplines to understand the biotope and upon the biological disciplines (Zoology, Botany, and Microbiology) to study the biocenosis. Additionally, it needs to incorporate social sciences to analyze the interactions between the human world and the biosphere. Thus, highly distinct disciplines are associated and orchestrated within ecological science (Morin, 2017, p. 28)

It is appropriate to emphasize that we are not interested in promoting dogmas or persuasion, but rather in breaking away from incomplete and crystalized knowledge. According to Nicolescu (1999), the study of living nature demands a new methodology. The animal issue, in addition to transcending disciplinary boundaries, encompasses significant problems of our time, undoubtedly contributing to the enrichment of the course and the formation of citizens who are more free and critical regarding ethical and global issues. Therefore, it is important to stimulate debates that address environmental, nutritional, and biochemical themes, to which the roles of animals are inherently connected to, although not always emphasized.

Methodological Approaches

In order to explore how the animal issue can be addressed in the context of undergraduate Chemistry, the aim of this study was *to conduct a survey to understand how professors in Chemistry programs at public institutions of higher education in the state of Minas Gerais, Brazil, perceive the concepts of contextualization and interdisciplinarity, including aspects related to the animal issue, in their courses*. In this section, we will explain the step-by-step process of data collection, data analysis, and remaining relevant choices made during the study.

According to the 2018 Higher Education Census, the Brazilian higher education system consisted of 2,537 institutions distributed throughout the national territory. Out of this total, 299 units corresponded to public Universities, University Centers, Federal Institutes, Colleges, and Federal Centers of Technological Education (CEFET) (INEP, 2019). Through searches conducted using the e-MEC² system, it was found that Minas Gerais is currently the third Brazilian state with the highest number of public higher education institutions, ranking behind only São Paulo and Rio de Janeiro. This information alone suggests good representativeness.

² System where it is possible to monitor the Brazilian Higher Education Institutions accredited by the Ministry of Education.

Based on the inclusion criteria of only public Higher Education Institutions (HEIs) in Minas Gerais that offer in-person undergraduate courses in Chemistry Education, we identified a total of 16 institutions, comprising 21 campuses and 23 courses offered in both evening and full-time schedules. After obtaining this information, we gathered the curriculum matrices of each institution and selected courses that were related to the research topic. Upon review, 54 were designated to conduct the initial survey.

With the characteristics of the target population defined, we were able to create the data collection instruments. A questionnaire-based investigation consists of a set of questions that are submitted to individuals with the purpose of obtaining information about knowledge, beliefs, feelings, values, interests, expectations, aspirations, fears, current or past behavior, etc. (Gil, 2019, p. 121). This type of tool is predominantly designed for written use and is also self-administered. Furthermore, participants can respond to it at their convenience, without being exposed to the personal opinions of the interviewer (Gil, 2019).

In formulating the questionnaire, suggestions from Bell (2008) were used, and one of the mentioned considerations was the extra attention given to the formulation and positioning regarding sensitive issues, such as in our case, questions that directly mentioned veganism. This careful approach is essential to avoid invalidating the question, as the researcher's presumption can lead to untrue inductions for the participants.

After formulation and approval by the Research Ethics Committee with Human Subjects of the Federal University of Juiz de Fora³, we conducted a pilot study with the questionnaire to refine the tool and avoid confusing and ambiguous questions (Bell, 2008). In this stage, professors with a similar profile to the study population participated, and 7 questions directly related to their perceptions of participating in the research were added.

With the addition of 2 questions, the final structure of the questionnaire consisted of 14 questions, divided into 4 main sections: (i) Personal information (2 single-line and 1 open-ended question); (ii) Education (1 multiple-choice multiple-select question and 1 single-line question); (iii) Professional experience (4 single-line questions); and (iv) Teaching practice (2 Likert⁴ scale guided open-ended questions and 2 open-ended questions). The aims of the questionnaire were to define the participants' profiles, understand their conceptions and attitudes towards the theme of interdisciplinarity, and explore possibilities related to the animal theme.

By searching for the email addresses of each professor, we obtained contacts for 39 individuals who were active in 16 out of the 21 campuses targeted. With the return of 23 questionnaires, the responses were analyzed using content analysis, the steps of which will be discussed in the following sections.

³ Number 3,733,181.

⁴ Typically used in opinion research, it offers options for bipolar evaluation and in different magnitudes. One of the scales used in this study, for example, provided the following options: not important, slightly important, neutral, important, very important.

Analysis

In possession of the analysis material, in addition to consulting the received responses as we received them, the first step involved conducting a floating reading, which is characterized by a transversal view in order to let emerge initial impressions and establish relationships for subsequent categorization, as suggested by Bardin (2016).

After determining how the analysis corpus would be divided, described, and analyzed, and with the objectives in mind, we formulated provisional hypotheses. Their functions are heuristic, seeking to “administer the test” and enrich the exploration, thereby increasing the propensity for discovery. In summary, they help direct the guidelines in the sense of finding confirmations or refutations, and they were as follows:

- The professors, for the most part, had not yet considered the possibility of incorporating the animal issue into their courses.
- Although this possibility was raised by the research, the prevailing idea, at least initially, is that it is scarce or nonexistent.

These hypotheses are based on the fact that the ideals of the animal issue are not present in Brazilian mainstream culture. This situation in itself hinders the dissemination of knowledge associated with these ideals and, as a consequence, becomes a barrier to their inclusion in classrooms, whether in Chemistry Education courses or in those that are thought to be more inclined towards the subject, such as Veterinary Medicine.

- The professors agree that, in general, contextualization and interdisciplinarity are important resources for their courses.

The next step was the referencing of *indices*, which means identifying explicit mentions of the themes targeted by us, which makes it possible to develop *indicators*. In other words, since the aim of this section is to conduct a survey regarding the contextualization and interdisciplinarity related to the aspects of the animal issue, our indices were those moments when the responses referred to these themes, and the indicators were their frequency of occurrence. This is how we began to segment the texts into *units of analysis*.

From that point on, we carried out the processes of enumeration, classification, and aggregation. In other words, we systematically transformed the raw data into *units of meaning*, counted them, and based on that, defined the categories. The first units defined are the base units, also known as *coding*. In our case, they are snippets of phrases from the responses according to the discussed theme in those fragments. The techniques adopted here correspond to *thematic analysis*, often used to study motivations of attitudes, values, beliefs, and trends.

Given that the same content element should not be classified into more than one theme, in cases of ambiguity in the meaning of the elements, it becomes necessary to define *context units* as well. This other type of unit is superior to the units of coding, and its function is to facilitate the understanding of the meaning of the items within the context in which they are found.

Since the units of coding are *what* is counted, the rules of enumeration are the way *in which* we count. It was through this complementation that we were able to observe the presence or absence of thematic units of coding in the statements of different participants, the frequency of mentions, the intensity and direction in which they refer to the subject, and the order of appearance in the statements, giving them meaning.

The division of messages into rubrics, although not a mandatory step, composes most of the procedures of *categorical content analysis*. The categorization process is an operation of classifying elements through differentiation and subsequent regrouping according to their similarities. Its stages involve inventory, in which we isolate the elements, and classification, dividing these elements while seeking a certain organization for the messages and simplification of raw data. Considering that the questions in the questionnaires sought direct and explicit responses according to our aim, categorization involved a low level of theorization, with margins of personal interpretation and subjectivity controlled through collaborative work.

We also decided, as will be seen, to adopt quantitative indicators in order to complement the qualitative approach and enrich the results. This type of analysis is based on the frequency of appearance of certain elements in the messages, from which we obtain descriptive, direct, and precise data through a statistical method.

Based on the analysis, we created 3 categories and 7 subcategories: (i) The animal issue and its interweaving, with the subdivisions (i.i) *Allusion to animals* and (i.ii) Animals as subjects of rights; (ii) Pedagogical practices in the classroom, with the subcategories (ii.i) *Relationship between interdisciplinarity, context, and contextualization*, (ii.ii) Inherent nature of the course, (ii.iii) General interpretations; and (iii) Perceptions about contextualization and interdisciplinarity, with the subdivisions (iii.i) Interdisciplinarity and (iii.ii) Contextualization. For the sake of brevity, we will present here the subcategories i.i and ii.i.

The final stages of the analysis revolved around treating the results in a way that would make them valid. An important part of this process is inference, a technique guided here by the *senders*, in our case, the professors who responded to the questionnaires; by the *receivers*, represented by us; and by the *messages* themselves, formed by codes. Inferences are not focused on the visible signs, but on the indices produced involuntarily. They are based on questioning the causes or antecedents and the possible effects of the message, and the role of the analyst is to work with the indices highlighted during the process, deducing logically from the facts. The interest of content analysis, therefore, is not merely the description of the contents, but what they can teach us after being treated.

Overview of Participants and Initial Discussions

Among the 23 participants, 21 chose their own pseudonyms. Regarding their academic background, 14 have completed a degree in Chemistry Education, 10 have obtained a bachelor's degree in Chemistry, and 11 hold other academic titles. In terms of further education, 4 have a master's degree and the rest are doctoral degree holders.

Their areas of expertise vary and may be related to chemical knowledge, environmental studies, sciences, and biochemistry. For the purpose of analysis, the professors were also divided into 2 groups based on the main theme of the courses they teach. Among them, 13 focus on environmental topics (such as Environmental Chemistry; STS Approach and Environmental Education for Teacher Training; Teaching Environmental Chemistry; Basic Ecology; and Environment and Social Responsibility), and 10 teach in the biological field (courses such as Biochemistry; Fundamentals of Biochemistry; and Biological Chemistry).

The professors also provided information about their teaching experience and how long they had been responsible for the courses relevant to the research. The responses varied, with some participants having taught for 30 years, while others had less than 1 year of experience. However, the majority had been teaching these subjects for more than 2/3 of their total teaching experience.

Also regarding the quantitative data, the professors expressed their opinions on the relationship between interdisciplinarity and classroom learning using a Likert Scale of importance. Among the 13 professors responsible for environmental disciplines, approximately half responded that interdisciplinarity is very important for learning, while the others considered it important. On the other hand, out of the 10 professors in the biological field, 9 tended to consider it very important, while only 1 viewed the relationship as important. The results were similar, with no responses indicating insignificance, little importance, or neutrality.

Another question, also based on a Likert Scale, aimed to gauge the professors' perceived ease/difficulty of using contextual teaching in comparison to other courses offered in the program. The responses showed more variation, with the majority in both groups considering it easier or much easier (13 professors). In contrast, 5 of them found it more difficult or much more difficult, and 3 perceived the same degree of difficulty/ease.

Regarding animals, the professors were asked whether there was any research in their discipline's field of study that mentioned the subject, whether related to food, the environment, or any other aspect. 20 educators were aware of studies that made such references. It is worth noting that one of them responded, "not that I know of," indicating that she recognizes the possibility of such research existing, although she may not have come across it. It is also worth considering the possibility that the respondents associated the question with the animal issue, specifically the obligation to discuss it from the perspective of animal welfare and rights, which is a relatively scarce topic.

Even though their previous answers may have been negative, the professors were invited to think further and consider the possibility of addressing animal rights issues in their courses. Thirteen participants responded positively, while seven responded negatively. Additionally, two responses appeared to be intermediate, as one participant stated that it is possible but does not believe the discussion should be part of the discipline, while another indicated that she had not yet thought about the subject. It is

also worth highlighting two negative responses, as one participant stated that she does not see the possibility but is interested in learning more, while another mentioned never having addressed the topic despite believing it to be possible.

The Animal Issue and its Interweaving

As previously mentioned, here we will present a selection of the overall analysis, focusing on the subcategories “*Allusion to animals*” (derived from the broader category “*The animal issue and its interweaving*”) and “*Relationship between interdisciplinarity, context, and contextualization*” (found within the category “*Pedagogical practices in the classroom*”).

Not only in this category, but also in the others, the majority of the units of coding found are present in specific questions. For example, while interdisciplinarity and contextualization can be observed in all responses, the animal issue was only mentioned when directly asked about. This is because, unlike an open-ended interview that allows interviewees to freely elaborate on the topics, the questionnaires were designed to obtain more restrained and direct information. It is important to emphasize that this fact does not make the data and analysis less appropriate, but rather guides them according to the peculiarities and needs of this research.

For this specific category, the units of coding represented, whether directly or indirectly, each moment in which animals were mentioned. For example, Professor Márcia presented four contexts in which they are addressed in her area of expertise as an educator. Ananda provided one example and indicated that it is possible to approach it in two different ways. Thus, these responses yielded 4 and 2 units of coding, respectively, related to the present category.

Allusion to Animals

When asked about research in their field that mentions animals, 2 professors were vague in pointing out that the literature addresses this topic in various ways without providing specific examples, while 1 suggested the possibility only indirectly. However, the assertive manner in which one of the participants expressed himself, namely Professor Felipe, suggests confidence that there are indeed many studies in the field of ecology that revolve around the topic.

The course of ecology constantly discusses studies that mention animals. (Professor Felipe Leite's statement)

The chemistry of life, in general, can be extrapolated to animal life. (Professor Tayana's statement)

Moving on to the examples of topics in these studies, the statements of the professors in environmental areas could be grouped and presented here in eight topics:

- Chemical analysis of metals and organic compounds from plant or animal samples with environmental interest.

- Contexts that recognize animals as beings inserted in the environment; therefore, important for their balance and other environmental processes. This example was mentioned by 2 educators, with 1 specifying the impact of livestock animals on environmental balance, highlighting the need to use less impactful and more ecological systems.

Professor Michael mentions this topic when discussing the impacts of anthropic action on the environment. His position drew attention for being the only one among the responses of the other participants in the environmental field that brought humans to the forefront. In addition to this, his statement seems to bring both the aspect of accountability and the role as a co-author of change:

Indirectly yes, because I discuss a lot about the impact of anthropic action on the environment. [...] Towards the end of the course, when I explicitly contemplate environmental education, sustainability, and social ecology, I seek to provide the dimension that scientific knowledge allows as a tool for environmental interpretation and intervention. (Professor Michael's statement)

The impacts generated by animal farming for consumption were alluded to by 3 professors when referencing livestock waste management and, more specifically, soil contamination by their excreta. The Environmental Impact Report of Animal Farming and Consumption (Schuck & Ribeiro, 2018) presents disturbing data on the subject, such as the fact that in the state of Santa Catarina, over 75 million liters of excreta and untreated effluents are released daily from swine farming. One of the impacts was that 95% of surface water sources in the West of Santa Catarina were contaminated by coliforms in 2009. When released on land, this waste infiltrates the soil, contaminating groundwater, reservoirs, and aquifers. When dumped into water, in addition to contaminating it, they give rise to a process called eutrophication (Schuck & Ribeiro, 2018, p. 25).

Not only that, in addition to contamination by fecal coliforms and production waste disposal, animal farming waste also contains residues of hormones and antibiotics frequently found as contaminants in groundwater, surface water, and tap water, and associated with endocrine and reproductive complications in fish and the emergence of antibiotic-resistant bacterial strains. The waste production is also responsible for another type of pollution associated with the volatilization of its compounds. Among the atmospheric pollutants are ammonia, methane, volatile fatty acids⁵, hydrogen sulfide, nitrous oxide, and CO₂. Besides being associated with respiratory complications in humans, these gases have other negative environmental impacts, such as the formation of acid rain due to ammonia discharge into the atmosphere and the increase in greenhouse gas emissions (Schuck & Ribeiro, 2018, pp. 25–26).

As the complexity of the topics is woven, it becomes possible to relate them to the points brought up by other participants. The responses of 3 professors fit into this context, as they mentioned the participation of animals in air pollution, greenhouse

⁵ The main source of energy for ruminants is volatile fatty acids (VFAs) produced in the rumen through microbial fermentation of carbohydrates and, in some cases, proteins, with acetic, propionic, and butyric acids being the primary ones (Berchielli et al., 2006).

effect, and global warming. It is also possible to notice that the examples complement each other in a cause-and-effect relationship, with global warming > greenhouse effect > air pollution.

- Use of veterinary medications.
- Endocrine disruptors that alter the hormonal systems of animals such as reptiles, birds, mammals, fish, among others. Also known as disruptors or regulators, they are artificial substances capable of modifying the normal functioning of the endocrine system by mimicking hormones. Their occurrence and exposure come through medications, pesticides, and everyday products, with Bisphenol A being an example.
- The relationship between deforestation and the migration of species from natural to urban environments was also brought up by a professor. This topic was not explored by the other interviewees, but it is a reality experienced by the educator herself:

[...] here in the city, there are macaws that came to the urban environment because of deforestation for sugarcane plantations. (Professor Catarina's statement)

- The study of compound toxicity and how animals can be affected was mentioned three times. One of the professors provided her response based on two real situations. The first one was discussed in the context of an investigative report on the use of pesticides, and the second focused on the effects of industrial mercury discharge:

Just like the example presented in Rachel Carson's book Silent Spring, which is a milestone in the environmental movement, it describes the indiscriminate use of agrochemicals causing various forms of animal life poisoning. For instance, it made birds infertile. Another example studied is the Minamata disaster (Japan), one of the worst environmental catastrophes involving the food chain, due to Hg poisoning caused by the disposal of waste containing this metal in Minamata Bay. As a result of consuming contaminated fish, birds in the region began to lose motor coordination, while cats started running in circles and foaming at the mouth. Subsequently, various effects were also observed in humans, especially among fishermen in the area and their families. (Professor Maria's statement)

In a succinct manner, Maria brought up the issue of pesticides, totaling three mentions among all the responses. Furthermore, the question related to the trophic cascade and the subsequent contamination of animals within that food web was directly cited by a total of two participants. Two examples were given specifically in reference to the topic of mercury biomagnification in aquatic environments, and a generic mention of aquatic pollution and its effects on animals was made by one professor.

Finally, one of the professors referred to the contamination of animal-derived food by dioxins and other Persistent Organic Pollutants (POPs). These POPs are synthetic substances, including certain pesticides, with specific characteristics such as high toxicity and bioaccumulation in the body through air or diet. Dioxins, in turn, are

byproducts of industrial processes and can also be produced through waste incineration and fires. The main source of human exposure to dioxins is the consumption of meat and dairy products, as animals are contaminated, for example, through grazing on pasture that has been affected by a polluted atmosphere, even in locations far from the sources of the pollutants.

- Biogeochemical cycles were mentioned by 2 professors, with one of the explanations focusing on the need to include the role of animals in terms of respiration, feeding, and decomposition.
- The extinction of animals, such as bees, was brought up by Catarina as an example. In her writing, the professor explained that this topic has already outreached scientific research and has become a subject of popular interest that can be brought into the classroom within the context of Science, Technology, and Society (STS):

I usually work with an episode of the series Black Mirror that deals with the extinction and creation of robotic bees. Despite the fiction, the extinction of bees is a real issue, so, based on the episode, I address the theme of animal extinction in the context of STS. (Professor Catarina's statement)

Focusing on the process of pollination by bees, Goulson et al. (2015) analyze the stress that these animals have been experiencing due to climate change, infectious diseases, and insecticides. Overall, the richness of wild bee species and other pollinators has decreased in the last 50 years, with some species becoming extinct. During this period, the demand for insect pollination in crop production has tripled, making their importance increasingly apparent. Consequently, there has also been growing concern that we might be on the brink of a crisis where crop yields will decline. Among the causes are habitat loss, resulting in reduced abundance and diversity of floral resources and nesting opportunities; exposure to an increasing number of parasites and pathogens inadvertently transported by human activities worldwide; and the intensification of agriculture and consequent growing use of pesticides, to which the pollinators are chronically exposed.

It is interesting to note that several of the examples presented by the participants are interconnected. For instance, the extinction of pollinators is related to the use of pesticides, which in turn relates to the topic of toxicity through the trophic chain. As we inevitably bring up the importance of animals to a properly balanced environment, we create a cycle. Environmental courses, as evidenced by the professor's statements, are closely linked to the subject of animals.

Meanwhile, the examples provided by the professors from biological disciplines can be categorized into the following seven topics:

- Difference between viruses and living organisms such as mammals and non-mammals, bacteria, and fungi.
- In terms of human nutrition, the responses of three professors stood out. One possibility lies in the necessity and influence of each food group in the

dynamics of biomolecule replenishment and energy supply for organisms. Professor Rajesh, for example, briefly mentioned having discussed veganism with his students during a class discussion on diets.

Normally, we study animal metabolism more intensively, but the topic of animal rights is not usually discussed. We have briefly discussed it as a secondary topic within discussions on diets, where we touched upon veganism. (Professor Rajesh's statement)

In the same vein as the complementary topics, one of the participants mentioned:

In the Digestive Biochemistry course in Medicine, I address aspects of nutrition. However, in the Chemistry course, I don't talk much about it because the syllabus of the subject does not include amino acid metabolism and nothing about digestion. The topic may come up in the metabolism section when the class shows more interest in nutrition, and I briefly cover protein metabolism. (Professor Ana's statement)

It is interesting to note that, even though certain topics are not included in the courses syllabi, lesson plans, and teaching plans, which are previously planned, the dynamics and diversity present in the classroom not only allow but also demand that discussions expand. The animal issue, the central theme of this research, can arise both in an idealized form and spontaneously according to the flow of the class.

- How molecules are produced and transformed in the human organism and, for the purpose of comparison, in other animals.
- Another example, raised by 2 professors, relates to cellular metabolism. It is common, among the teaching plans of biochemical courses, to study the metabolism of carbohydrates, lipids, and amino acids. However, the way the content is presented varies based on several factors. For instance, in his speech, Rajesh indicates that he considers it relevant to extend the content beyond the human system, while Professor DB brings animals into the discussion through nutrition. On the other hand, Professor Irene justified the lack of studies that touch on animals through the fact that the focus of the course is on humans.

Usually, we study animal metabolism more extensively. (Professor Rajesh's statement)

Yes, in the metabolism classes, while discussing the main oxidative pathways and amino acid metabolism, we address animal protein consumption. (Professor DB's statement)

The course is focused on Human Biochemistry. (Professor Irene's statement)

- Before studying the catabolism of macromolecules (carbohydrates, lipids, and proteins), there is a consideration for how and where they are digested, as well as how they are absorbed.
- Animal adaptation and characteristics in response to the environment were explored by Professor Londe:

[...] we study producers, consumers, energy acquisition systems in environments with higher or lower oxygen concentration, and even its absence. The adaptations of animals in various terrestrial environments based on climate and environmental geography, in other words, dietary adaptations in response to natural factors. (Professor Londe's statement)

- Finally, the experimentation and medicinal use of animals were brought up through 5 examples by 2 participants. When analyzing their statements, we noticed that the intentions behind each response were different, allowing us to see both the purpose of discussing certain topics related to experimentation and the intention to debate the trials themselves.

First, Professor Ana stated that she brings up animals as part of the history of enzymology (the study of specialized proteins that catalyze biological reactions) when discussing the early studies on proteases (enzymes that break peptide bonds between amino acids in proteins), which were initially conducted using animal proteases, and how they were treated compared to the present. Another example takes place when explaining experiments in general, such as the transfer of genetic information of *Streptococcus* bacteria in rats. In the same line, the third possibility goes back to the early extraction of insulin from pigs and intersects with the current method of producing synthetic human insulin using bacteria.

Furthermore, Professor PFP, identified by her initials, mentioned the following possibilities among her examples:

We can discuss what and why we can test viability only in vitro and not employ animal testing. We can talk about the importance of using animals to validate molecular transformations within organisms (animal testing). (Professor PFP's statement)

In other words, there is (i) the possibility to discuss, as a counterpoint to the use of animals, reasons and feasibilities for in vitro testing, outside living systems, and (ii) the importance of animals for certain tests. It is noted, at first, how the examples can be contradictory, with one advocating alternatives to animal experimentation while the other supports it, considering the specificities of the subjects studied.

The discussions surrounding animal experimentation are certainly controversial. To better contextualize this, we refer to a memorable event that took place in 2012 during a conference in Cambridge, where physicist Stephen Hawking (1942-2018) was the guest of honor. Starting with the initial writing by neuroscientist Philip Low, along with 25 other internationally recognized professionals in the field, they all signed a manifesto regarding consciousness in non-human animals. Their understanding was based on the fact that the same structures responsible for consciousness in humans are found in invertebrate creatures such as octopuses and other mollusks, as evidenced by various research in the field. In other words, other animals are capable of experiencing the world in their own way. In the body of the manifesto, it is pointed out that

The absence of a neocortex does not appear to preclude an organism from experiencing affective states. Convergent evidence indicates that non-human animals have the neuroanatomical, neurochemical, and neurophysiological substrates of conscious states along with the capacity to exhibit intentional behaviors. Consequently, the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness. Non-human animals, including all mammals and birds, and many other creatures, including octopuses, also possess these neurological substrates (Low et al., 2012)

As for his famous statement that “it is no longer possible to say that we did not know”, we make Low’s words our own. In keeping with the aforementioned principles, the neuroscientist declares that one of the probable changes arising from the impacts of the Cambridge manifesto would be:

In the long run, I believe that society will rely less on animals. It will be better for everyone. Let me give you an example. The world spends \$20 billion per year on killing 100 million vertebrates for medical research. The probability of a drug resulting from these studies being tested on humans (only testing, it may not even work) is 6%. It’s a terrible cost-benefit ratio. A first step is to develop non-invasive approaches. I don’t think it’s necessary to take lives to study life. I believe we need to appeal to our own ingenuity and develop better technologies to respect animal life. We have to put technology in a position where it serves our ideals instead of competing with them.⁶

Indeed, there are various types of tests to which animals are subjected, often heavily criticized. Vivisection, for instance, is the term used to describe the dissection of living animals, and it is also used to refer to various forms of animal experimentation involving mice, guinea pigs, primates, pigs, dogs, cats, rabbits, fish, chickens, cows, and horses, among others.

According to Greif and Tréz (2000), the major sponsors of vivisection are connected to healthcare, the agricultural sector, and military practices. In the chemical industry, one example is toxicity tests, conducted to determine whether certain chemicals are safe for humans and at what dosage. Other tests include eye and skin irritation tests, carcinogenicity and mutagenicity studies, teratogenicity and reproductive toxicity studies, hepatotoxicity and nephrotoxicity studies, neurotoxicity tests, among others.

Continuing on the education perspective, the purposes of animal experimentation are diverse, including the observation of physiological phenomena, behavioral studies, understanding internal anatomy, and improvement of surgical skills (Greif & Tréz, 2000). Legally, these practices are required to be followed by euthanasia, meaning that animals subjected to vivisection are then desensitized and given analgesia before being slaughtered.

6 Pires, M. T. (6 de maio, 2016). “Não é mais possível dizer que não sabíamos”, diz Philip Low. *VEJA*. <https://veja.abril.com.br/ciencia/nao-e-mais-possivel-dizer-que-nao-sabiamos-diz-philip-low/>

Furlan and Fischer (2020) see the use of animals for academic purposes in studying well-known biological processes as a legitimization of the belief that these beings are not sentient. Even though academic techniques may be reliable, the advancement of scientific knowledge and changing perceptions have generated repudiation and intolerance towards the act of taking the lives of healthy beings merely to repeat consolidated processes (Furlan & Fischer, 2020, p. 3). The majority of experiments can be replaced by technological alternatives involving simulations, mannequins, and interactive videos, without compromising learning. Moreover, this approach saves time, financial resources, reduces ecological impact, as has the benefits associated with fostering sensitive and responsible professionals. According to Greif and Tréz (2000), supplemented by Furlan and Fischer (2020), the barriers to the substitution of animals are rooted in the lack of information and discussion about alternatives, limited exposure to student discontent with these practices, and the technician and utilitarian thinking of educators, students, and society as a whole.

Pedagogical Practices in the Classroom

This category refers to the professors' accounts of their practices in the classroom. Specifically, the units analyzed here are mostly related to the question of whether there is planning aimed at bringing interdisciplinarity into the classroom. Following the principle of content analysis, in which each unit of coding should belong to only one category, we did not include responses that directly discussed animals, which were covered in the first category, even though they may involve related practices. However, it will be possible to establish connections between the categories later on.

Relationship Between Interdisciplinarity, Context, and Contextualization

The creation of this subcategory is based on a common idea found in the responses, in which the concepts of interdisciplinarity, context, and contextualization are sometimes used interchangeably. This connection can be observed when some professors explain how interdisciplinarity is included in their classes:

Relating to everyday life. (Professor Chemistry's statement)

I seek elements and situations from everyday life to contextualize the content covered in the classroom, and interdisciplinarity is always present in our day-to-day. (Professor Camila's statement)

Although our aim is not to problematize how the interviewees perceive interdisciplinarity, we have noticed that a significant portion of the conceptions converge in considering it as (i) a methodological tool for learning scientific concepts, (ii) synonymous with contextualization, and in the same sense, (iii) primarily associated with the connection between the topic being studied and some everyday situation — thus, an exemplification. Once the terms are not clearly understood in their concepts, they become not only blurred but also shallow, thereby preventing the appropriation and command of the bodies of knowledge.

Our observations resemble the findings discussed by Wartha and colleagues (2013), who analyzed texts addressing everyday life, contextualization, and assumptions related to the teaching of Chemistry, reflecting on these themes. Firstly, in order to understand the terms in their specificities, the authors conceive of everyday life as the relationship between daily situations and scientific knowledge. From 1999 onwards, the term began to be replaced by contextualization, used to incorporate a reference to a text; thus, embedding learning and reality in their connections, making them intrinsic, and whose meaning is lost when separated. In this way, a new conception of school knowledge is sought.

The results of the selected texts suggested that even certain textbooks appropriate the idea that contextualization is limited to exemplification and illustration of everyday facts. Moreover, many educators understand it as a scientific description of everyday life and use it as a synonym for context. The criticism of these views, according to the adopted perspective, is based on the reductionist conception of their roles, with the understanding of social reality being secondary to the teaching of chemical knowledge. In this sense, only superficial relationships are established between them.

The authors, then, argue that contextualization should not be adopted merely as a resource or methodological approach but as a guiding principle for exploring the contextualized theme in its potential and transcending the surface. As Pereira and Santos Menezes (2022, p. 104) state, this signifies a more complex understanding than mere exemplification or a superficial presentation of contexts without problematization that effectively provokes the search for understanding of the study topics. According to the approach used by Wartha et al. (2013, pp. 88–89), where alienation can only be prevented through reflection on everyday life, what is sought is a transformative education, as advocated by Paulo Freire, that implies the development of pedagogical practices filled with meaning, strongly linked to problematizing real and contradictory situations in local contexts. The contradictions need to be critically understood through dialogicity between learners and educators, which gains strength to act towards transforming this reality. Therefore, a study of everyday life is not merely about exemplifying aspects of people's daily lives. It is also not about using everyday life as a tool to motivate students to learn scientific content, much less disguising the teaching of chemistry with facts and phenomena from everyday life.

This is how contextualization can be seen as a guiding principle, as well as through other perspectives such as the Science, Technology, and Society (STS) approach, everyday life, and historical and sociological bases of the sciences. Since there are various legitimate approaches, we agree with the authors' conclusion regarding the need for awareness in order for the teacher to assume their role as an active mediator in the learning process.

In line with these thoughts, Professor Sibeles Augusta, despite equating the concepts of interdisciplinarity and contextualization, believes that classroom practices can help students better understand current topics through a more in-depth and careful study.

By contextualizing with current topics, which are often superficially presented in the media. (Professor Sibebe Augusta's statement)

On the other hand, Professor PFP seems to bring a teaching perspective in which the scientific theme is closely associated with everyday life, rooting them together. This view aligns with the thoughts of Wartha et al. (2013, p. 85), who criticize using this approach in a secondary role, that is, serving as mere exemplification or illustration to teach chemical knowledge.

Every semester, we complement the discussions with topics from scientific and non-scientific "journals", discussing "trendy" topics that influence daily life. We connect molecular structures and their functionalities to aspects of health and disease, linking nutritional aspects/intake or exclusion of nutrient components to the maintenance and recovery of human health. (Professor PFP's statement)

Furthermore, Professor Rajesh seeks to start from the experiences and interests of the students, designing an approach tailored to that group based on contextual, interdisciplinary, and STS perspectives, among others. From there, they address more holistic aspects and explore possibilities between teaching, research, and extension. Similarly, Professors DB and Tayana view interdisciplinarity, everyday life, and contextualization as tools that can relate to each other. They do not see these concepts as analogous but rather as complementary when appropriate.

Initially, I listen to the students regarding their demands in the curriculum, as biochemistry allows for different approaches in different courses. Based on the students' demands, we work in a more contextualized and interdisciplinary manner. We often work with aspects of biochemistry related to diets, exercises, or metabolic diseases. In these cases, the STS approach has been used to promote interdisciplinarity by involving not only the curricular units in the Chemistry area but also units from the education area, such as Inclusive Education, Pedagogical Practice, etc. An example was a project where students studied the metabolism of three metabolic diseases and worked on an awareness project about these diseases, creating brochures and presenting them to the community. (Professor Rajesh's statement)

I always bring examples of biochemistry applied to practical/daily life issues and related to other areas of knowledge. In addition to the examples in the classroom, I work with the students on proposing an interdisciplinary project to solve a societal demand using a technology or an invention based on biochemistry. (Professor DB's statement)

I try to relate the content of the course to everyday life themes and show that other areas are also important for understanding that theme. For example, in understanding metabolism, we also need to know basic concepts of thermodynamics (taught in

Physical Chemistry), chemical equilibrium (Analytical Chemistry), stoichiometry (General Chemistry), chemical bonding (Inorganic Chemistry), and Lewis acid-base concepts (Organic Chemistry). (Professor Tayana's statement)

Furthermore, Professor Tayana's statement draws our attention to how the understanding of a specific subject in the curriculum (metabolism) requires dialogue not only with Biology and Chemistry but also with other sub-areas such as Physical Chemistry. Its complex nature aligns with Morin's (2017) ideas of multidimensional, polyscopic, systemic, poly- and transdisciplinary sciences, capable of leading us to various perspectives that simultaneously converge in their organizing nature. The disciplines discussed here have the characteristic of having syllabi and program contents that naturally demand knowledge from other fields, further complexifying the topics.

The same object — an organism — is simultaneously a physical (atomic), chemical (molecular), biological (macromolecular), physiological, mental, social, and cultural object. The emergence of interdisciplinary fields is another key factor. Since 1945, a significant number of fields with a multi- or interdisciplinary character have evolved. Examples range from studies in the area, women's studies, environmental studies, urban studies, and cultural studies to social psychology, political sciences, criminology, and gerontology to cognitive sciences and information sciences, materials science, and molecular biology (Klein, 2004, p. 3).

According to Klein (2004), the historical separation of disciplines is still inherent to the way universities function, but it is eroding and becoming obsolete in some areas. The internal development of sciences imposes increasingly interconnected tasks between the natural, social, and technical sciences. As mutual relations are considered, new levels of organization are revealed. After all, interdisciplinarity is a natural and internal requirement of the sciences, in the sense of a better understanding of the reality it allows us to know (Fazenda, 2012, p. 91).

Some Considerations

In relation to interdisciplinarity in the classroom, certain practices adopted by professors caught our attention, such as approaching topics based on students' experiences and interests. Its importance has been linked to: the interconnection between environmental/biochemical concepts and knowledge that are part of other courses present both in the Chemistry Education program and outside of it; assisting in the learning process; supporting problem-solving; providing new perspectives and making mundane concepts more interesting and dynamic for students.

Furthermore, most professors find it easier to adopt an interdisciplinary or contextual approach in their disciplines compared to other courses. Among the arguments that caught our attention are their strong relationships with, for instance, Qualitative Analytical Chemistry, Toxicology, Organic Chemistry, Physical Chemistry, and General Chemistry. On the other hand, one professor pointed out that Environmental Chemistry is comprehensive and requires knowledge from various fields, which makes interdisciplinary or contextual integration more challenging.

With respect to the research conducted in the areas of study of the disciplines offered by the interviewees, examples of animal-related themes were mentioned, such as recognizing animals as beings integrated into the environment, being important for its balance and directly affected by harmful anthropic actions; negative environmental impacts related to the meat industry; trophic poisoning, biomagnification, and bioaccumulation by pesticides, mercury, and dioxins; animal extinction and its impacts; human nutrition and dietary habits; and experimentation.

Concerning the animal issue itself, it was understood that the theme not only can be addressed in the classroom but is already present. Possibilities that stood out include animal experimentation and a problematization approach; investigation of animal abuse; exploring the tendency of respect and ethics; scientific development and production of synthetic meat; economic and social issues related to livestock farming; and understanding that human beings are also animals whose ecological importance and rights should not be greater than those of other beings.

The justifications against the inclusion of the animal question revolve around its limited relevance to the course. While some professors acknowledge the possibility of its inclusion in their disciplines, many do not consider it pertinent to work on it. Furthermore, the topic was not spontaneously brought up in the questionnaire but only mentioned when specifically asked about. Rajesh was the only professor who not only indicated having addressed animal issues through veganism in the classroom but also explained his experience.

We understand, based on the responses, that the animal issue can emerge spontaneously during the course of a lesson. It is interesting to note that many of the examples presented recognize the importance of other animals for an environmentally balanced world. In agreement, studies involving environmental disciplines are more connected to consideration for animals, even though there may be a self-centered interest, as in the case of the food chain and POPs. On the other hand, studies related to biological disciplines are somewhat more linked to exploitation, such as experiments for educational purposes.

We conjecture that, based on the consensus among the interviewees, *the acknowledged importance of interdisciplinarity opens doors for the inclusion of animals to help solve problems, make the discipline more interesting and appealing, interconnect knowledge, and contribute to the teaching and learning process.*

Although it was not our intention to judge the interdisciplinary or contextual nature of the shared practices, we noticed that some conceptions converge in considering them as methodological tools focused on the teaching of scientific concepts, synonymous and primarily linked to everyday life in terms of examples, which can make the concepts shallow, confusing, and thus misunderstood. Additionally, we consider it important to note that a genuinely interdisciplinary project requires foundations such as clarity, coherence, detail, intention, dialectics, and partnership.

Based on these considerations, we undertake a process of revisiting our initial provisional hypotheses — one of the stages proposed by Bardin (2016) in conducting content analysis — in order to confirm or refute the validity of those theories: most professors had not yet considered the possibility of incorporating the animal issue into their courses; even though such possibility was raised by the research, the prevailing idea, at least initially, is that it is scarce or non-existent; the professors agree that, in general, contextualization and interdisciplinarity are important resources for their courses.

Regarding the first two hypotheses, we observed that 13 out of 23 interviewees reported seeing the possibility of including animal rights in their subjects. This number is irresolute, however, and it is interesting to note that when asked about the existence of studies that at least touched upon animals, regardless of the perspective, 20 professors responded positively. Through qualitative analysis, we understand that only 2 educators have had such experience in the classroom, while the remaining 11 were able to propose possibilities. However, we cannot affirm whether these suggestions will remain in the realm of ideas or if any educator intends to bring them into practice.

Based on the analyzed information, we consider that the first hypothesis cannot be confirmed or refuted. This is because only 2 interviewees, whose responses were counted as negative regarding the possibility of integrating the animal issue, stated that they had not yet considered it. The positive responses, on the other hand, do not settle this inquiry, as the reflection on examples may have been prompted by the questionnaire's stimulus. Nevertheless, the level of acceptance and the various possibilities presented exceeded our expectations, leading us to perceive that the professors' responses tend to refute the second hypothesis. Finally, the third hypothesis was confirmed, as all the interviewees recognize the importance of interdisciplinarity and contextualization as allies in the teaching-learning process.

The discussions led us to other hypotheses that were not evident in the initial reading. This circumstance was foreseen by Bardin (2016), who reminds us of the back-and-forth characteristic of the analysis between theory, technique, hypotheses, and methods. Furthermore, our reality constitutes *one* point of view, *one* dimension of the analysis, a particular and very restricted approach to a very limited subject (Bardin, 2016, p. 80). The analysis encompasses a multitude of dimensions and possible techniques, making it unfeasible to exhaust the discourse. Therefore, what we present is a woven possibility, allowing us to corroborate the underlying assumptions.

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References

- Bardin, L. (2016). *Análise de conteúdo* (L. A. Reto, & A. Pinheiro, Trad.). Edições 70.
- Bell, J. (2008). *Projeto de pesquisa: Guia para pesquisadores iniciantes em educação, saúde e ciências sociais* (M. F. Lopes, Trad.). Artmed.
- Berchielli, T. T., Pires, A. V., & Oliveira, S. G. (2006). *Nutrição de ruminantes*. Funep.
- Fazenda, I. C. A. (2012). *Interdisciplinaridade: história, teoria e pesquisa*. Papyrus.
- Fernandes, K. G., & Flôr, C. C. C. (2020). O veganismo, a questão animal e a educação em ciências na educação básica: Um olhar para a literatura da área. In I. B. de Oliveira, M. D. Pletsch, T. V. Pereira, & Y. Ribeiro (Orgs.), *Didática(s) entre diálogos, insurgências e políticas: tensões e perspectivas na relação entre novas epistemologias, biodiversidade, diferença, democracia e inclusão* (pp. 1296–1303). Faperj/CNPq/Capes/Endipe/DP et Alii.
- Fernandes, K. G., Freitas-Reis, I., & Sousa, R. A. (27 de setembro a 01 de outubro, 2021). *A questão animal e a Licenciatura em Química: Uma revisão sistemática* [Apresentação de trabalho]. XIII Encontro Nacional de Pesquisa em Educação em Ciências (ENPEC).
- Furlan, A. L. D., & Fischer, M. L. (2020). Métodos alternativos ao uso de animais como recurso didático: Um novo paradigma bioético para o ensino da zoologia. *Educação em Revista*, 36, e230590, 1–22. <https://doi.org/10.1590/0102-4698230590>
- Gil, A. C. (2019). *Métodos e técnicas de pesquisa social*. Atlas.
- Goulson, D., Nicholls, E., Botías, C., & Rotheray, E. L. (2015). Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science*, 347(6229), 1255957. <http://dx.doi.org/10.1126/science.1255957>
- Greif, S., & Tréz, T. (2000). *A verdadeira face da experimentação animal: sua saúde em perigo*. Sociedade Educacional Fala Bicho.
- Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP). (2019). *Censo da Educação Superior 2018: Notas estatísticas*. https://download.inep.gov.br/educacao_superior/censo_superior/documentos/2019/censo_da_educacao_superior_2018-notas_estatisticas.pdf
- Japiassu, H. (2006). *O sonho transdisciplinar: E as razões da filosofia*. Imago.
- Klein, J. T. (2004). Interdisciplinarity and complexity: an evolving relationship. *Emergence: Complexity and Organization*, 6(1), 2–10.
- Low, P., Panksepp, J., Reiss, D., Edelman, D., Van Swinderen, B., & Koch, C. (2012). *Francis Crick Memorial Conference*. <http://fcmconference.org/#>
- Morin, E. (2017). *A cabeça bem-feita: repensar a reforma: reformar o pensamento* (E. Jacobina, Trad.). Bertrand Brasil.

- Nicolescu, B. (1999). *O manifesto da transdisciplinaridade* (L. P. Souza, Trad.). Triom.
- Parecer CNE/CES 1.303/2001 (2001). Diretrizes Curriculares Nacionais para os Cursos de Química. <http://portal.mec.gov.br/sesu/arquivos/pdf/130301Quimica.pdf>
- Pereira, B. S. A., & Santos Menezes, J. M. (2022). Livro didático de química e contextualização no ensino médio: prática docente em um município do Amazonas (Brasil). *Revista Ensino de Ciências e Humanidades — RECH*, 6(1), 101–117. <https://periodicos.ufam.edu.br/index.php/rech/article/view/10058>
- Schuck, C., & Ribeiro, R. (2018). *Comendo o planeta: Impactos ambientais da criação e consumo de animais*. Sociedade Vegetariana Brasileira.
- SVB. (20 de maio, 2020). *Pesquisa do IBOPE aponta crescimento histórico no número de vegetarianos no Brasil*. <https://www.svb.org.br/2469-pesquisa-do-ibope-aponta-crescimento-historico-no-numero-de-vegetarianos-no-brasil>
- SVB. (2 de agosto, 2021). *Brasileiros reduzem consumo de carne; estabelecimentos se adaptam, revela IPEC*. <https://www.svb.org.br/2648-brasileiros-reduzem-consumo-de-carne-estabelecimentos-se-adaptam-revela-nova-pesquisa-do-ipecc>
- Wartha, E. J., & Faljoni-Alário, A. (2005). A contextualização do ensino de química através do livro didático. *QNEsc*, (22), 42–47. <http://qnesc.sbq.org.br/online/qnesc22/a09.pdf>
- Wartha, E. J., Silva, E. L., & Bejarano, N. R. R. (2013). Cotidiano e contextualização no ensino de química. *QNEsc*, 35(2), 84–91. http://qnesc.sbq.org.br/online/qnesc35_2/04-CCD-151-12.pdf

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