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Integrating Natural Science Teaching Knowledge for Planetary Health Education: A Study in a Riverside Community in the Amazon

Integração de Conhecimentos de Ensino de Ciências Naturais Para uma Educação em Saúde Planetária: Estudo em uma Comunidade Ribeirinha da Amazônia

Integración de los Conocimientos de la Enseñanza de las Ciencias Naturales en la Educación Para la Salud Planetaria: Un Estudio en una Comunidad Ribereña de la Amazonia

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Abstract

This research aims to investigate the integration of prior knowledge among elementary school students in a riparian community in the Amazon, within the context of five crucial domains for Planetary Health Education. Data collection was conducted through a questionnaire comprising nine open-ended questions, administered to 9th-grade students in the southwest region of Amazonas, Brazil. Analyses were performed using Nvivo 1.5 software, in conjunction with relative frequency. The results indicated that the students from the riverside communities have a strong identification with the nature that surrounds them, and that this inclusion in science teaching is fundamental. Furthermore, they identified and reported the main environmental challenges faced by the local community. It was observed that slightly over half of the students understand the direct relationship between environmental impacts and human health. They also expressed awareness of their rights and proposed necessary changes to mitigate local environmental impacts. Based on the data discussed within the context of Planetary Health, the need to pay special attention to these students living in rural environments through scientific literacy is highlighted. Many of them still lack a full understanding of the environmental impacts affecting their future, their rights, and the crucial importance of considering an interconnected planet.

Keywords: Amazon, rural education, planetary health, science education, nature

Resumo

Esta pesquisa tem como objetivo investigar a integração dos conhecimentos prévios de estudantes do ensino fundamental em uma comunidade ribeirinha na Amazônia, no contexto de cinco domínios cruciais para a Educação em Saúde Planetária. A coleta de dados foi conduzida por meio de um questionário com nove perguntas abertas, aplicado aos estudantes do 9º ano do Ensino Fundamental na região sudoeste do Amazonas, Brasil. As análises foram realizadas utilizando o *software* Nvivo 1.5, juntamente com a frequência relativa. Os resultados indicaram que os estudantes ribeirinhos possuem uma forte identificação com a natureza que os cerca, sendo fundamental essa inserção no ensino de ciências. Além disso, eles identificaram e relataram os principais desafios ambientais enfrentados pela comunidade local. Foi observado que um pouco mais da metade dos estudantes compreende a relação direta entre os impactos ambientais e a saúde humana. Eles também expressaram consciência dos seus direitos e sugeriram mudanças necessárias para minimizar os impactos ambientais locais. A partir dos dados discutidos dentro do contexto da Saúde Planetária, destaca-se a necessidade de direcionar atenção

especial a esses estudantes que vivem em ambientes rurais por meio da alfabetização científica. Muitos deles ainda não têm plena compreensão dos impactos ambientais que afetam o futuro, seus direitos e a grande importância de considerar um planeta interconectado.

Palavras-chave: Amazônia, saúde planetária, educação científica, natureza

Resumen

Esta investigación tiene como objetivo investigar la integración de los conocimientos previos de estudiantes de educación primaria en una comunidad ribereña en la Amazonía, en el contexto de cinco dominios cruciales para la Educación en Salud Planetaria. La recopilación de datos se realizó a través de un cuestionario con nueve preguntas abiertas, administrado a estudiantes de noveno grado de la educación primaria en la región suroeste de Amazonas, Brasil. Los análisis se llevaron a cabo utilizando el software Nvivo 1.5, junto con la frecuencia relativa. Los resultados indicaron que los alumnos de las comunidades ribereñas tienen una fuerte identificación con la naturaleza que les rodea, y que esta inclusión en la enseñanza de las ciencias es fundamental. Además, identificaron y reportaron los principales desafíos ambientales enfrentados por la comunidad local. Se observó que un poco más de la mitad de los estudiantes comprenden la relación directa entre los impactos ambientales y la salud humana. También expresaron conciencia de sus derechos y sugirieron cambios necesarios para minimizar los impactos ambientales locales. A partir de los datos discutidos en el contexto de la Salud Planetaria, se hace hincapié en la necesidad de prestar especial atención a estos estudiantes que viven en entornos rurales mediante la alfabetización científica. Muchos de ellos aún no tienen una comprensión completa de los impactos ambientales que afectan su futuro, sus derechos y la importancia vital de considerar un planeta interconectado.

Palabras clave: Amazonía, educación rural, salud planetaria, educación científica, naturaleza

Introduction

Rural Education in Brazil, regulated by the National Education Guidelines and Bases Law (LDB) n. 9.394/1996, aims to provide Basic School Education for the diverse rural populations. This educational system should be flexible, adapting to the peculiarities of each region, including curriculum, innovative teaching methods, and school calendars. It is crucial to consider production cycles, climatic conditions, and integration with the labor activities inherent to rural areas.

The rural populations, including traditional groups such as riparian dwellers, indigenous peoples, and quilombolas, possess a vast and valuable repository of ancestral knowledge about their environment. This encompasses modes of production, food consumption, use of plants, and environmental stewardship. The integration of these traditional knowledges, if well incorporated, has great potential for achieving scientific literacy aligned with Planetary Health.

Teaching in rural areas, as highlighted by Arroyo (1999), requires a constructive approach centered on the rural subject. This implies considering local environmental, political, historical, economic, and cultural aspects, aiming to ensure high-quality education. In the state of Amazonas, the Amazonas Curricular Reference (RCA) of

2019 promotes 'Rural, Waters, and Forest Education', prioritizing education aligned with the reality of rural communities. The document proposes processes of listening and dialogue to integrate various areas of knowledge in an interdisciplinary manner, preparing students to actively participate in their own learning through a curriculum in constant (re)construction.

The relationship between Rural Education and Science Education is extremely significant, considering that both play a role in the development of communities and the understanding of the natural world. This enables the promotion of sustainable development in rural communities and allows students to understand and value the environment in which they are situated. Additionally, they acquire essential scientific skills and knowledge to address the challenges posed by the contemporary world. Both areas are essential for Science Education, as they encompass aspects such as interdisciplinarity, contextualization, connections with the environment, development of practical skills, technological innovations, inclusion, and empowerment.

To strengthen the connections of Science Education in Rural Education, it is highlighted the importance of students being scientifically literate. In this context, Chassot (2003) points out that scientific literacy is the ability to read nature, enhancing an education committed to different possibilities of associating scientific knowledge with reality. Thus, scientifically literate individuals can understand the world around them and be an active voice in decision-making on scientific and technological issues.

The teaching of science in rural schools contributes to the scientific literacy of students when it is able to integrate different knowledge, wisdom, and practices. Authors such as Sasseron & Carvalho (2008) and Laugsch (2000) highlight the basic axes for the proposal of scientific literacy, which are: the basic understanding of terms, knowledge, and fundamental scientific concepts; the understanding of the nature of science and the ethical and political factors surrounding its practice; and the understanding of the relationships between science, technology, society, and the environment. According to these axes, the importance of science is reinforced, which is intrinsically linked to the scientific knowledge of students, allowing investigations of phenomena and reflection on them.

The fundamental importance of Rural Education, focusing on the inhabitants of these areas, highlights the relevance of addressing topics of Planetary Health, especially in Science Education. This field of study and action seeks to understand and propose solutions to the environmental impacts caused by human activities, which have a direct impact on the future of humanity (Whitmee et al., 2015). This approach is both theoretical and practical, adopting an interdisciplinary and transdisciplinary perspective (Health, 2017), which effectively realizes Science Education through the integrated understanding of the language of nature in its context.

To guide education in Planetary Health at all levels of education, researchers in this field have developed five key domains, namely: interconnectedness through nature, the Anthropocene and health, systemic and complexity thinking, equity and justice, and movement-building and system change (Guzmán et al., 2021).

The domain 'Interconnectedness through nature' is central and emphasizes the importance of respecting and valuing direct relationships with nature, including those based on mutualism, reciprocity, and symbiosis. This also encompasses the inclusion of various types of knowledge, including indigenous and native peoples' knowledge (Guzmán et al., 2021).

The domain 'Anthropocene and health' focuses on environmental impacts and their influence on human health. Examples of these impacts include climate change, loss of biodiversity, alterations in biogeochemical cycles, and global pollution, which have direct effects on disease patterns, encompassing non-communicable infections, reproductive issues, mental health, among others. This domain adopts a social and ecological approach to promote health, prevent, and control diseases, taking into account the determinants that affect both individuals and collectivities in terms of human, animal, and ecosystem health (Guzmán et al., 2021).

The domain 'Systemic thinking and complexity' addresses the interactions between elements of nature and human health at different geospatial and temporal scales. It promotes an interconnected view to understand the complex relationships between natural and social systems, enabling the conception and implementation of innovative solutions for Planetary Health (Guzmán et al., 2021).

The domain 'Equity and justice' emphasizes the importance of ensuring the rights of individuals and the rights of nature, so that all can achieve full vitality. It highlights the need to eliminate disparities in environmental impacts and health that disproportionately affect the most vulnerable populations, aiming to enable everyone to thrive (Guzmán et al., 2021).

Lastly, the fifth domain, 'Movement-building and system change,' plays a crucial role in shaping movements committed to addressing Planetary Health challenges. This domain emphasizes the importance of building a movement geared towards significant change and a transition to an equitable and sustainable future (Guzmán et al., 2021).

Scientific literacy, within the context of the domains presented above, is highly significant in empowering students to understand and critically evaluate the connections between health and the environment. This is essential for making informed decisions and participating in the construction of movements for change focused on promoting health and advocating for the environment.

In the context of the Amazon, issues of Planetary Health are urgent. Indeed, the tropical rainforest has frequently been the target of attacks due to anthropogenic actions, such as alarming rates of deforestation and wildfires (Hope, 2019; Fearnside, 2005; Santos, 2017), resulting in ecological disasters that include climate change, air, water, and soil pollution, contributing to environmental degradation and affecting global ecological balance (Lewis & Maslin, 2015). A series of events contributes to the occurrence of extreme weather events, increasing the region's vulnerability (Nobre et al., 2007; Marengo & Souza, 2018), directly affecting the health and well-being of local communities.

Issues related to Planetary Health are directly interconnected with Science Education, as they enable the integration of these five key domains with content and practices that can contribute to scientific literacy, such as the life knowledge of riparian students and their relationships with nature.

Hence, it is crucial to conduct research in rural communities and schools in the Amazon to address health issues, inequality, and basic rights. This underscores the need for an integrated and holistic approach to Planetary Health and Science Education in the region. Thus, this study aimed to promote the integration of prior knowledge of elementary school students from a riparian community in the Amazon with the five domains for Planetary Health Education.

Materials and Methods

Study Area

The study was conducted at a Riparian School in the Southern mesoregion of Amazonas state, Brazil, established by Ordinance n. 031/96, dated October 25, 1996. Located in a traditional riparian community, at geographic coordinates 6°20'25"S and 62°1'19"W.

Data Collection

The research was conducted in the first semester of 2023 with a group of 37 9th-grade students from a school in the Southern mesoregion of Amazonas state. Data were collected through a structured questionnaire with open-ended questions allocated to each respective domain (Figure 1). It is essential to emphasize that the questions were separated to better discuss each domain individually, but it is a model of interconnection between the domains.

The questionnaire was administered within a 50-minute time frame, provided by the teacher of the Natural Sciences subject.

Figure 1

Questions proposed in the questionnaire applied to the students

Order	Questions	Domain
Q1	Do you consider yourself part of nature? Justify.	Interconnectedness through Nature
Q2	Do you believe that there is rich knowledge about nature (animals, plants, water, soil, etc.) within the community?	
Q3	How do you think community residents relate to nature?	
Q1	Did you know that environmental changes are related to health?	Anthropocene and Health

Figure 1

Questions proposed in the questionnaire applied to the students (continuation)

Order	Questions	Domain
Q1	Do you think that community residents have their rights ensured?	Equity and Justice
Q2	Do you think that nature has its rights ensured?	
Q1	How do you explain the relationship between environmental changes in your community and health?	Systemic Thinking and Complexity
Q1	What can you do to minimize the environmental impacts that compromise the future of humanity?	Movement-building and System Change

Treatment and Analysis of Qualitative-Quantitative Data

The data were processed and entered Nvivo 1.5 software to be organized, coded, and generate results. To facilitate the understanding of the analyses performed, a word cloud was created in Nvivo 1.5 software displaying the most mentioned words in the questionnaires. Additionally, anonymous excerpts from the questionnaires are presented in the results. It is worth emphasizing that, in this latter case, the responses are associated with the following question from the questionnaire: 'Briefly describe an experience that represents your connection with nature?', which is also part of the questionnaire.

The quantitative data were consolidated and analyzed using relative frequency, which was represented through bar graphs.

Results

The word cloud (Figure 2) was created based on the students' responses after the questionnaires were administered, allowing us to identify the most frequently mentioned terms in the responses.

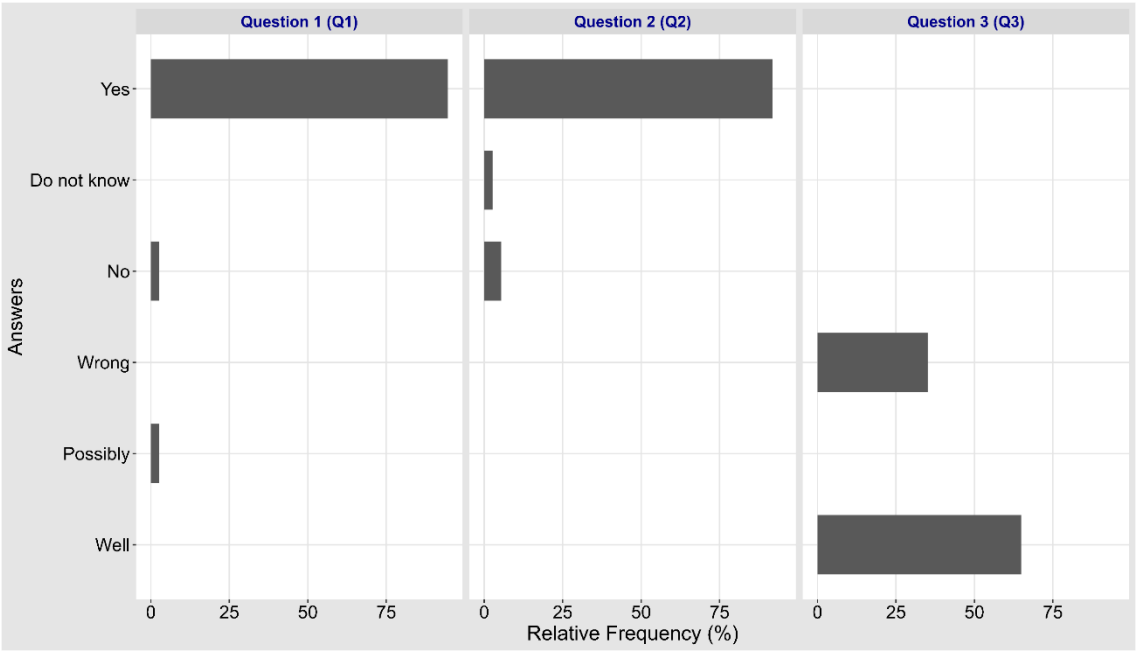
Figure 2

Word cloud generated by Nvivo software based on the questionnaire

About the domain of Interconnectedness through Nature, riparian students were asked if they consider themselves part of nature (Q1), and approximately 95% responded affirmatively. Regarding question Q2, which deals with the existence of comprehensive knowledge about nature, more than 90% responded positively. As for question Q3, which inquiries about the perception of the community's relationship with nature, about 65% believe that community members have a good relationship with nature, while 35%, with a good approximation, indicated that they do not have a good relationship (Figure 3).

Figure 3

Distribution of relative frequencies of responses to questions Q1 (Do you consider yourself part of nature? Justify.), Q2 (Do you believe that there is rich knowledge about nature (animals, plants, water, soil, etc.) within the community?), and Q3 (How do you think community residents relate to nature?) within the domain of Interconnectedness through Nature



In addition to the responses above, students were also encouraged to briefly share an experience of connection with nature. For this question, we selected some responses, as shown below.

"I climb trees and eat lots of fruits" (R2)

"When I plant a tree, it symbolizes my friendship with it" (R4)

"I enjoy being with nature because I like animals and walking through the forest" (R5)

"I like to swim in the lake" (R14)

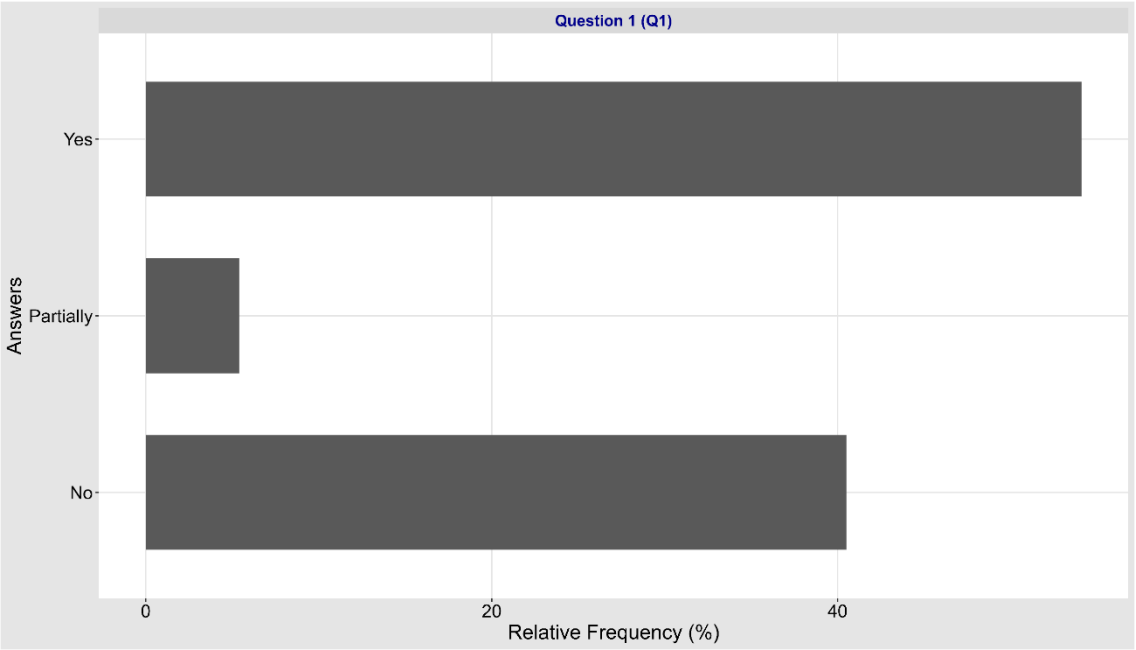
"Once I went fishing and caught a small fish, then I released it back into nature" (R20)

"I have several plants. When I wake up early in the morning to water them, I can smell the good scent of the trees in nature" (R32)

With respect to aspects of the Anthropocene and Health domain, approximately 54% of students perceive that environmental relationships are related to their health, meaning that environmental changes directly affect health. On the other hand, about 40% stated that they do not know. Finally, a small minority believe that there is partially a relationship between these aspects (Figure 4).

Figure 4

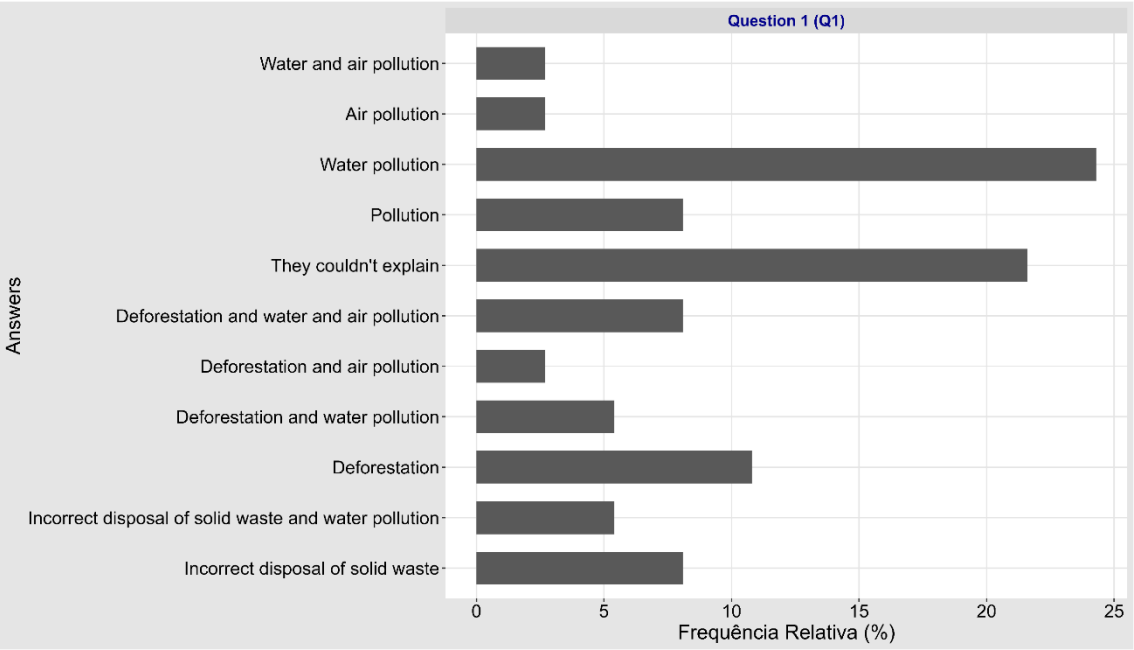
Distribution of relative frequencies of responses to question Q1 (Did you know that environmental changes are related to health?) within the Anthropocene and Health domain



In relation to inquiries within the Systemic Thinking and Complexity domain, students pointed out various local environmental problems, such as: water and air pollution (2.7%); air pollution (2.7%); water pollution (24.3%); pollution (8.1%); deforestation and water and air pollution (8.1%); deforestation and air pollution (2.7%); deforestation and water pollution (5.4%); deforestation (10.8%); improper disposal of solid waste and water pollution (5.4%); improper disposal of solid waste (8.1%); and, in addition to the problems mentioned, almost 22% of students did not know how to answer (Figure 5).

Figure 5

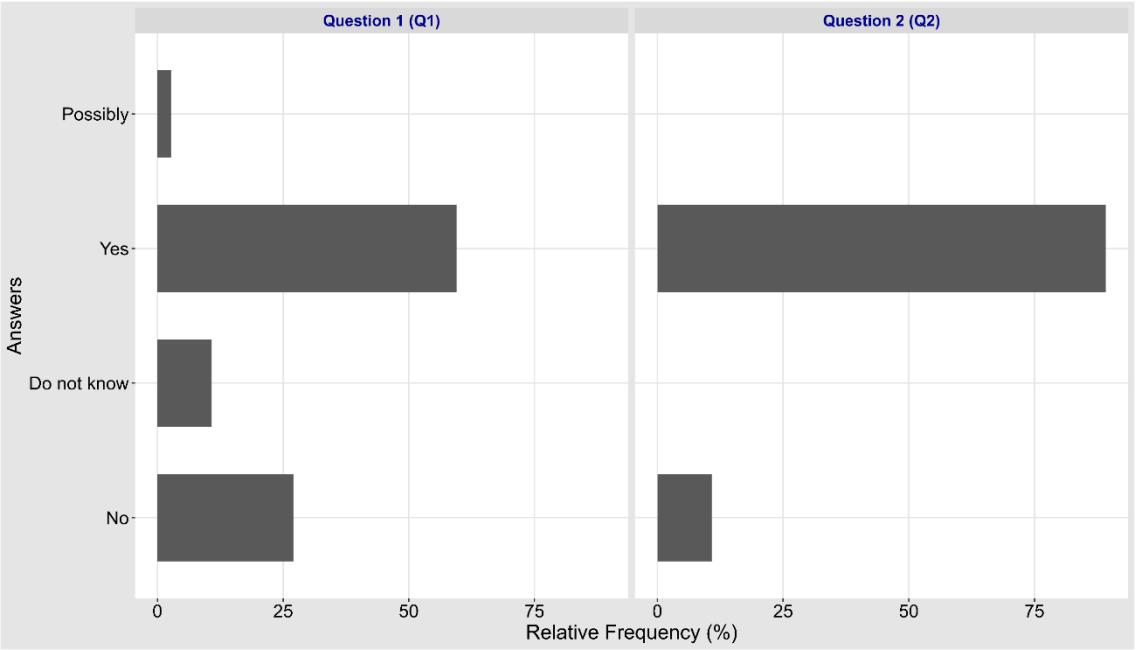
Distribution of relative frequencies of responses to question Q1 (How do you explain the relationship between environmental changes in your community and health?) within the Systemic Thinking and Complexity domain



In the perspective of the Equity and Justice domain, 59% affirmed that they believe their rights are guaranteed (Q1), and approximately 27% say they do not consider this right guaranteed. Regarding the rights of nature (Q2), about 89% mention that rights are ensured, and approximately 10% affirm that they do not believe nature has its rights ensured (Figure 6).

Figure 6

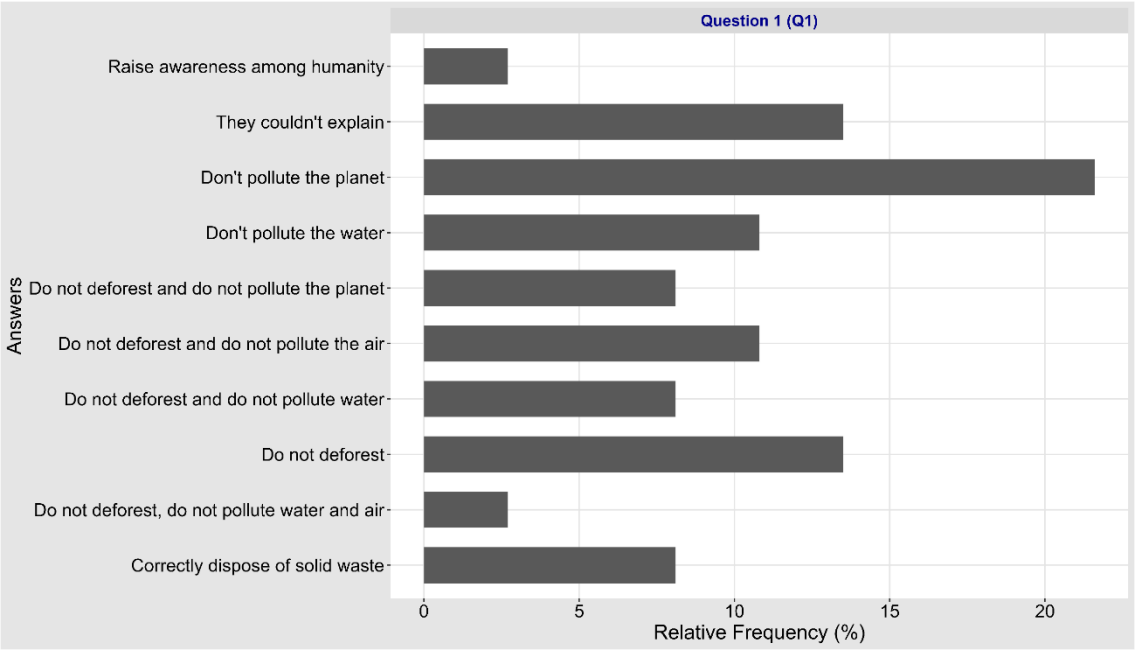
Distribution of relative frequencies of responses to questions Q1 (Do you think that community residents have their rights ensured?) and Q2 (Do you think that nature has its rights ensured?) within the Equity and Justice domain



In the perspective of the Construction of Movement and System Change domain, responses included various points, such as: raising awareness among humanity (2.7%); not polluting the planet (21.6%); not polluting water (10.8%); not deforesting and not polluting the planet (8.1%); not deforesting and not polluting the air (10.8%); not deforesting and not polluting water (8.1%); not deforesting (13.5%); not deforesting and not polluting air and water (2.7%); correctly disposing of solid waste (8.1%); and still, some did not know how to explain (13.5%) (Figure 7).

Figure 7

Distribution of relative frequencies of responses to question Q1 (What can you do to minimize environmental impacts that compromise the future of humanity?) within the Construction of Movement and System Change domain



Discussions

Studies involving young people in rural schools in the Amazon represent a promising approach to Planetary Health, as they enable the investigation of the main environmental challenges faced by communities, health issues, and the strategies adopted by Amazonian peoples to address such issues, in addition to fostering discussions about the rights of peoples and the crucial importance of mitigating the damages that compromise the future of humanity.

Figure 2 provides insights into natural resources and environmental impacts which are relevant to Planetary Health. In light of this, it is indispensable to include urgent themes in education at all levels, with emphasis on the context of the Amazon, one of the biomes that has been experiencing significant impacts and is approaching the point of no return — "tipping point," as indicated by Lovejoy & Nobre (2018).

Themes regarding natural resources and environmental impacts in the Amazon offer opportunities for scientific literacy as they allow students to surpass conceptual boundaries and empower them to critically understand local issues, promoting changes aimed at socio-environmental well-being.

Al Sultan et al. (2021) emphasizes that teachers are an inseparable link for a scientifically literate society. In this context, teachers, when addressing these environmental themes in Science Education, have the opportunity to investigate

established problems in their experiences and can systematize them with scientific knowledge. Sasseron & Carvalho (2008) highlight that teachers need to provide didactic proposals that allow students to outline pathways for learning. Thus, the proposal is mainly based on indicators for scientific literacy, among which the indicators of investigation, structuring of thought, and understanding of the analyzed issue stand out in this work.

When analyzing the integration of knowledge for Planetary Health Education within the context of an Amazonian riparian community by employing "Interconnedness through Nature," significant benefits for the physical and mental health of individuals are observed, promoting a healthy future for all (Guzmán et al., 2021).

Indeed, the results reflect the direct connection of students with nature, particularly evidenced in the examples of connections highlighted in the questionnaire, which involve relationships of care and responsibility. Research underscores that the greater the connection between humans and nature, the greater the desire for preservation and protection (Kleespies & Dierkes, 2023; Lengieza & Swim, 2021; Lumber et al., 2017; Schultz, 2002). Riparian students have valuable insights for health and well-being, making them protagonists of their learning process. Baena-Morales & Fröberg (2023) emphasize that instilling in students an awareness of sustainability and planetary health effectively contributes to lifelong competencies and values.

Rural schools play a crucial role in strengthening the connection between humans and nature by recognizing the diverse perspectives of students and the knowledge originating from indigenous peoples and other cultures. From the perspective of scientific literacy, this domain can be considered indispensable when associated with the sociocultural characteristics of these peoples. Chassot (2003, 2014) emphasizes that science education needs to value knowledge that can be easily communicated, enabling conditions for interdisciplinary and contextualized school practices.

This allows for a strong connection based on respect and care, influencing values and behaviors (Johnson & Cincera, 2023), bringing notable benefits for individuals, communities, and the planet as a whole. According to the research by Hinds & Sparks (2008), individuals who spend their childhood in rural communities tend to develop deeper emotional bonds, identification, and positive behaviors and attitudes towards nature.

In the context of the "Anthropocene and Health" domain, the advances achieved over the years in sectors such as health are at risk of being compromised due to the unrestrained exploitation of natural resources, which can have severe effects on Planetary Health. Therefore, it is important to emphasize that the planet is facing the greatest climate crisis ever recorded, considered the greatest health threat of the 21st century (Watts et al., 2022; IPCC, 2014; Chomsky et al., 2020). Thus, it is essential to understand the importance of education dedicated to environmental issues, especially in the face of the impacts caused by human actions and their visible effects on health.

In rural schools, it is crucial to motivate students to reflect on the interconnections between key environmental problems at both local and global scales, as well as the impacts of these challenges on health. This is particularly relevant in the Amazon, a forest of great importance for maintaining ecosystem services (Nobre et al., 2021). Therefore, it is essential for teachers to discuss with students that planet Earth has boundaries, and that humanity is exceeding them (Rockström et al., 2009), making people more susceptible to developing various diseases.

The domain of "Systems Thinking and Complexity" in rural schools can be understood through the analysis of numerous socio-environmental challenges and their connection with health. This domain aims for transdisciplinary approaches towards beneficial changes (Jochem et al., 2023). Furthermore, it underscores the importance of considering the life context of phenomena, seeking solutions to issues that currently represent significant threats both at the local and global levels.

The students were not specific when reporting environmental interactions and health, but they brought up various socio-environmental issues directly related to health. Therefore, it is possible to conduct discussions about the themes presented and consider possible future scenarios. It is noticeable that the obtained results highlight the issue of inadequate solid waste disposal, deforestation, and pollution of water and air.

In the riparian context of the students, it is common to observe the absence and/or precariousness of basic sanitation services (Melo et al., 2021). Thus, the issues raised by the students underscore the urgency of public policies aimed at pollution control. It is worth noting that the legal framework for basic sanitation in Brazil is represented by Law n. 11,445/2007, known as the Basic Sanitation Law. This legislation establishes national guidelines for basic sanitation and creates the structure for the sector in the country. Its goal is to achieve universal access to services such as drinking water supply, sanitation, urban cleaning, solid waste management, and urban drainage and rainwater management.

In relation to the population in rural areas and in the Amazon, the Basic Sanitation Law recognizes the need for special attention to these areas due to their specific characteristics. The law acknowledges that rural areas and environmental protection zones, such as the Amazon, may require differentiated solutions for basic sanitation, considering the local reality, environmental preservation, and improvement of the quality of life of the populations.

In the case of contaminated water, Luo et al. (2022) emphasize how developing countries need to implement water quality control in contaminated communities, aiming at environmental improvement, health, well-being, and sustainable development. Additionally, it is crucial to report that rural communities in the Amazon are currently experiencing an alarming scenario due to extreme drought, affecting over half a million people (G1, 2023).

The impacts of the water crisis affect river transportation, food and water scarcity, loss of biodiversity, as well as various diseases that proliferate, including waterborne diseases and respiratory illnesses resulting from fires and aerosol emissions (Lima et al., 2023; Marengo & Espinoza, 2016).

Regarding solid waste, there is an essential need for waste management and efforts to promote recycling (Ajay et al., 2022), considering numerous health problems related to improper waste disposal.

The deforestation identified by the students represents a global threat due to changes in ecosystems, loss of biodiversity, and endangerment of local residents' lives (Fearnside, 2005; Gomes et al., 2010). Another global concern is the exposure to air pollution, which has significant impacts on human health (Floss et al., 2019), including increased morbidity and the development of chronic diseases, reducing life expectancy, especially in individuals with pre-existing conditions (Brook et al., 2010).

In this highlighted perspective, this domain alludes to the locally presented environmental problems, endorsing the essentiality of connecting systems in pursuit of beneficial changes. In this sense, an approach to the themes through the indicators of scientific literacy allows students to articulate observations of local phenomena with the use of evidence, sensitizing them to find sustainable solutions (Marques & Xavier, 2020), conceived in the relationships of integration between environment and health.

Within the domain of "Equity and Justice," which stands out as one of the most evident and actionable aspects in the rural context, both various communities and the school itself serve as emblematic examples. This is due to the striking inequalities that permeate various spheres, including the environmental degradation faced by these communities, often driven by greed and speculation, which harms planetary well-being. Specifically concerning students, it is possible to empower them to become agents in the fight for equity and justice in their communities, promoting responsible and resilient local development (Guzmán et al., 2021).

The results indicate a lack of information about the rights of humans and nature for students, especially when considering the environmental impacts felt by more vulnerable populations. Stone et al. (2018) point out that the negative effects of environmental changes are experienced unequally among populations on geographical and temporal scales. In this context, educational processes need to recognize existing inequalities in order to prioritize most affected populations and ecosystems (Jochem et al., 2023). Lastly, it is understood how essential it is to include or strengthen environmental themes in students' curricula so that they can understand the effects of environmental impacts on human and environmental health.

Educators can create meaningful learning experiences that not only promote scientific literacy but also empower students to become informed and engaged citizens committed to protecting human rights and nature. Examples include contextualizing human rights and nature preservation, problematizing the ethical and social implications of scientific issues, establishing connections across different areas of knowledge, and

understanding how scientific issues are intertwined with human rights and nature. Additionally, promoting classroom debates allows students to express their views, share experiences, and present different perspectives on scientific issues related to human rights and nature.

In the domain "Building Movement and Systems Change," there is no doubt about the need to restore planet Earth to ensure the survival of future generations, avoiding the greatest collapse in history. "We have no time to waste. There is no reason for inaction, as we have enough knowledge to act now" (Saraiva, 2021, p. 2), with scientific literacy being a promising approach.

The São Paulo Declaration on Planetary Health (2021) highlights the need for everyone to engage in actions that build a movement for change and the great transition to a more sustainable and just future (Myers et al., 2021). It is crucial to profoundly change the system, each within their respective areas, but in an interconnected manner.

In Basic School Education, there is a significant audience representing the future (Melo et al., 2022), and it is essential to encourage them to become leaders in planetary actions (Faiesall et al., 2023). This is a positive and strategic step to stimulate changes in the system and to disseminate Planetary Health within communities. It is crucial to incorporate Planetary Health into transdisciplinary approaches with students to help define the field of Planetary Health (Tilleczek et al., 2023).

Conclusions and Implications

The findings of the study endorse the essentiality of re(thinking) the significance of Planetary Health education as a promising pathway within the realms of Science Education. Scientific literacy emerges to contribute to fostering a broader and more holistic understanding of human and environmental health. This is particularly crucial given the urgency for mitigation and adaptation to the significant environmental crisis prevailing on the planet, jeopardizing the future of all.

The experiences encountered in this study prompt reflection on how education centered on environmental issues and their interconnections provide knowledge, values, and practices in the face of this new geological era, the Anthropocene (Guzmán et al., 2021). The data from the studies reveal the value of connections through nature for the physical and mental health of individuals. Furthermore, understanding the extent to which local and global environmental crises relate to population health is crucial, as it allows for awareness of the problem, sensitization, and development of future actions towards a sustainable planet.

The suggestions highlighted by this study reinforce an education that is based on nature, with participatory, investigative, and transdisciplinary approaches, and above all, proposals that are decolonial and consider all knowledge and experiences, aiming at scientifically literate students. The inclusion of proposals tailored to the local context of riparian students allows for reflection on the past, present, and future in the community, thus, dialogues pave the way for understanding problems and more engagement in promising actions.

Therefore, it is important to conduct further research that establishes connections between Science Education and Planetary Health Education, especially in Rural Education. An example that could be considered in future research is the Science, Technology, and Society (STS) approach, as it focuses on the complex interaction between science, technology, society, and the environment.

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References

Al Sultan, A., Henson Jr, H., & Lickteig, D. (2021). Assessing preservice elementary teachers' conceptual understanding of scientific literacy. *Teaching and Teacher Education*, *102*, 103327. https://doi.org/10.1016/j.tate.2021.103327

Ajay, S. V., Kirankumar, P. S., Varghese, A., & Prathish, K. P. (2022). Assessment of dioxin-like POP's emissions and human exposure risk from open burning of municipal solid wastes in streets and dumpyard fire breakouts. *Exposure and Health*, *14*, 763–778. https://doi.org/10.1007/s12403-021-00450-4

Arroyo, M.G., & Fernandes, B. M. (1999). *A Educação básica e o movimento social do campo* (2ª ed.). Articulação Nacional por uma Educação Básica do Campo.

Amazonas. (2019). *Referencial Curricular Amazonense*. http://www.cee.am.gov.br/?page_id=902

Baena-Morales, S., & Fröberg, A. (2023). Towards a more sustainable future: simple recommendations to integrate planetary health into education. *The Lancet Planetary Health*, *7*(10), e868–e873. https://doi.org/10.1016/S2542-5196(23)00194-8

Brook, R. D., Rajagopalan, S., Pope, C. A., Brook, J. R., Bhatnagar, A., Diez-Roux, A. V., Holguin, F., Hong, Y., Luepker, R. V., Mittleman, M. A., Peters, A., Siscovick, D., SmithJr, S. C., Whitsel, L., & Kaufman, J. D. (2010). Particulate matter air pollution and cardiovascular disease: an update to the scientific statement from the American Heart Association. *Circulation*, *121*(21), 2331–2378. https://doi.org/10.1161/CIR.0b013e3181dbece1

Chassot, A. (2003). Alfabetização científica: uma possibilidade para a inclusão social. *Revista Brasileira de Educação*, (22), 89–100, 2003. https://doi.org/10.1590/S1413-24782003000100009

Chassot, A. (2003). *Educação e consciência*. Edunisc.

Chassot, A. (2014). Saber científico/Saber escolar/Saber primevo. In J. V. A. de Souza, & R. Guerra (Eds.), *Dicionário Crítico da Educação* (pp. 243–247). Dimensão.

Chomsky, N., Pollin, R., & Polychroniou, C. J. (2020). *Crise climática e o Green New Deal global: a economia política para salvar o planeta*. Editora Roça Nova.

Faiesall, S. M., Ahmad Tajuddin, S. H., George, A. J., Marzuki, N. H., Lacey-Hall, O., Mahmood, J., & Guinto, R. (2023). Mobilising the Next Generation of Planetary Health Leaders: The Dynamism of Youth Engagement in Malaysia. *Challenges*, *14*(1), 18. https://doi.org/10.3390/challe14010018

Fearnside, P. M. (2005). Desmatamento na Amazônia brasileira: história, índices e consequências. In P. M. Fearnside (ed.), *Destruição e Conservação da Floresta Amazônica* (pp. 7–19). INPA.

Floss, M., Barros, E. F., Fajardo, A. P., Bressel, M., Hacon, S., Nobre, C., Soranz, D., Saldiva, P., Patrício, K. P., Knupp, D., Boeira, L., Watts, N., McGushin, A., & Beagley, J. (2019). Lancet Countdown: briefing para políticas de saúde no Brasil. *Revista Brasileira de Medicina de Família e Comunidade*, *14*(41), 2286–2286. https://doi.org/10.5712/rbmfc14(41)2286

G1. (2023). *Seca severa no Amazonas já afeta mais de meio milhão de pessoas, aponta Defesa Civil.* https://g1.globo.com/am/amazonas/noticia/2023/10/16/seca-severa-no-amazonas-ja-afeta-mais-de-meio-milhao-de-pessoas-aponta-defesa-civil.ghtml

Gomes, J. M., Carvalho, J. O. P. D., Silva, M. G. D., Nobre, D. N. V., Taffarel, M., Ferreira, J. E. R., & Santos, R. N. J. (2010). Sobrevivência de espécies arbóreas plantadas em clareiras causadas pela colheita de madeira em uma floresta de terra firme no município de Paragominas na Amazônia brasileira. *Acta amazônica*, *40*(1), 171–178. https://doi.org/10.1590/S0044-59672010000100022

Guzmán, C. A. F., Aguirre, A. A., Astle, B., Barros, E., Bayles, B., Chimbari, M., El-Abbadi, N., Evert, J., Hackett, F., Howard, C., Jennings, J., Krzyzek, A., LeClair, J., Maric, F., Martin, O., Osano, O., Patz, J., Potter, T., Redvers, N., ... Zylstra, M. (2021). A framework to guide planetary health education. *The Lancet Planetary Health*, *5*(5), e253–e255. https://doi.org/10.1016/S2542-5196(21)00110-8

Health, T. L. P. (2017). Welcome to the lancet planetary Health. *The Lancet Planetary Health*, *1*(1), e1. https://doi.org/10.1016/s2542-5196(17)30013-x

Hinds, J., & Sparks, P. (2008). Engaging with the natural environment: The role of affective connection and identity. *Journal of Environmental Psychology*, *28*(2), 109–120. https://doi.org/10.1016/j.jenvp.2007.11.001

Hope, M. (2019). The Brazilian development agenda driving Amazon devastation. *The Lancet Planetary Health*, *3*(10), e409–e411. https://doi.org/10.1016/S2542-5196(19)30195-0

IPCC (2014). Summary for policymakers. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K. L. Ebi, Y.O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandea, & L. L. White (Eds.), *Climate change 2014: Impacts, adaptation, and vulnerability. Part a: Global and Sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change* (pp. 1–32). Cambridge University Press . https://www.ipcc.ch/site/assets/uploads/2018/02/ar5_wgII_spm_en.pdf

Jochem, C., von Sommoggy, J., Hornidge, A. K., Schwienhorst-Stich, E. M., & Apfelbacher, C. (2023). Planetary health literacy: a conceptual model. *Frontiers in Public Health*, *10*, 980779. https://doi.org/10.3389/fpubh.2022.980779

Johnson, B., & Činčera, J. (2023). Relationships between outdoor environmental education program characteristics and children's environmental values and behaviors. *Journal of Adventure Education and Outdoor Learning*, *23*(2), 184–201. https://doi.org/10.1080/14729679.2021.2001756

Kleespies, M. W., & Dierkes, P. W. (2023). Connection to nature of university students in the environmental field—An empirical study in 41 countries. *Biological Conservation*, *283*, 110093. https://doi.org/10.1016/j.biocon.2023.110093

Laugksch, R. C. (2000). Alfabetização científica: Uma visão conceitual. *Educação em Ciências*, *84*(1), 71–94.

Lima, L. S., de Oliveira, H. F. M., Fleischmann, A. S., & Macedo, M. N. (2023). Extreme drought is again isolating people in Amazonia. *Nature*, *622*(7984), 697. https://doi.org/10.1038/d41586-023-03311-z

Lei Nº 11.445, de 5 de Janeiro de 2007 (2007). Estabelece as diretrizes nacionais para o saneamento básico; cria o Comitê Interministerial de Saneamento Básico; altera as Leis nos 6.766, de 19 de dezembro de 1979, 8.666, de 21 de junho de 1993, e 8.987, de 13 de fevereiro de 1995; e revoga a Lei nº 6.528, de 11 de maio de 1978. (Redação pela Lei nº 14.026, de 2020). https://www.planalto.gov.br/ccivil_03/_ato2007-2010/2007/lei/l11445.htm

Lei Nº 9.394, de 20 de Dezembro de 1996 (1996). Estabelece as diretrizes e bases da educação nacional. https://www.planalto.gov.br/ccivil_03/leis/l9394.htm

Lengieza, M. L., & Swim, J. K. (2021). The paths to connectedness: A review of the antecedents of connectedness to nature. *Frontiers in Psychology*, *12*, 763231. https://doi.org/10.3389/fpsyg.2021.763231

Lewis, S. L., & Maslin, M. A. (2015). Defining the Anthropocene. *Nature*, *519*, 171–180. https://doi.org/10.1038/nature14258

Lovejoy, T. E., & Nobre, C. (2018). Amazon tipping point. *Science Advances*, *4*(2), eaat2340. https://doi.org/10.1126/sciadv.aat2340

Luo, Y., Wu, J., & Xu, Y. (2022). Can self-governance tackle the water commons? —Causal evidence of the effect of rural water pollution treatment on farmers' health in China. *Ecological Economics*, *198*, 107471. https://doi.org/10.1016/j.ecolecon.2022.107471

Lumber, R., Richardson, M., & Sheffield, D. (2017). Beyond knowing nature: Contact, emotion, compassion, meaning, and beauty are pathways to nature connection. *PLoS One*, *12*(5), e0177186. https://doi.org/10.1371/journal.pone.0177186

Marengo, J. A., & Souza Junior, C. (2018). *Mudanças Climáticas: impactos e cenários para a Amazônia*. https://www.oamanhaehoje.com.br/assets/pdf/Relatorio_Mudancas_Climaticas-Amazonia.pdf

Marengo, J. A., & Espinoza, J. C. (2016). Extreme seasonal droughts and floods in Amazonia: causes, trends and impacts. *International Journal of Climatology*, 36(3), 1033–1050. https://doi.org/10.1002/joc.4420

Marques, R., & Xavier, C. R. (2020). Alfabetização científica no ensino de Ciências: uma sequência didática sobre a pegada ecológica do lixo. *Revista de Ensino de Ciências e Matemática*, *11*(2), 84–106. https://revistapos.cruzeirodosul.edu.br/rencima/article/view/2504

Melo, P. R. H., Batista, E. R. M., & Camargo, T. S. (2021). Educação do Campo e o Ensino de Ciências: Experiências em uma escola ribeirinha no Sul do Estado do Amazonas. *Revista Brasileira de Educação do Campo*, *6*, e9760. https://doi.org/10.20873/uft.rbec.e9760

Melo, P. R. H., de Camargo, T. S., Lima, R. A., Abreu, T. F., & Santiago, R. D. A. C. (2022). Exploring educators' perception of issues involving Planetary Health: A qualitative study in the Brazilian Amazon. *International Health Trends and Perspectives*, *2*(3), 61–80. https://doi.org/10.32920/ihtp.v2i3.1680

Myers, S. S., Pivor, J. I., & Saraiva, A. M. (2021). The São Paulo declaration on planetary health. *The Lancet*, *398*(10308), 1299. https://doi.org/10.1016/S0140-6736(21)02181-4

Nobre, C. A., Sampaio, G., & Salazar, L. (2007). Mudanças climáticas e Amazônia. *Ciência e Cultura*, *59*(3), 22–27. http://cienciaecultura.bvs.br/scielo.php?script=sci_arttext&pid=S0009-67252007000300012&lng=en&tlng=pt

Nobre, C., Encalada, A., Anderson, E., & Neves, E. G. (2021). *Science panel for the Amazon: Amazon Assessment Report 2021: executive summary*. United Nations Sustainable Development Solutions Network. https://ainfo.cnptia.embrapa.br/digital/bitstream/item/226222/1/27201.pdf

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., Lenton, T. M., Scheffer, M., Folke, C., Schellnhuber, H. J., Nykvist, B., Wit, C. A., Hughes, T., van der Leeuw, S., Rodhe, H., Sörlin, S., Snyder, P. K., Costanza, R. Svedin U., ... Foley, J. A. (2009). A safe operating space for humanity. *Nature*, *461*(7263), 472–475. https://doi.org/10.1038/461472a

Santos, T. O. (2017). Os impactos do desmatamento e queimadas de origem antrópica sobre o clima da Amazônia brasileira: um estudo de revisão. *Revista Geográfica Acadêmica*, *11*(2), 157–181. https://revista.ufrr.br/rga/article/view/4430

Santos, L. L., Magalhães, O. H. F., Fleischmann A. S., Macedo, M.N. (2023) . Extreme drought is again isolating people in Amazonia. *Nature*, *622*(697). https://doi.org/10.1038/d41586-023-03311-z

Saraiva, A. M. (2021). Saúde planetária: a informática na saúde tem muito a contribuir. *Journal of Health Informatics*, *13*(4). https://jhi.sbis.org.br/index.php/jhi-sbis/article/view/916

Sasseron, L. H., De Carvalho, A. M. P. (2008). Almejando a alfabetização científica no ensino fundamental: a proposição e a procura de indicadores do processo. *Investigações em Ensino de Ciências*, *13*(3), 333–352. https://ienci.if.ufrgs.br/index.php/ienci/article/view/445

Schultz, P. W. (2002). Inclusion with nature: The psychology of human-nature relations. In P. Schmuck & W. P. Schultz (Eds.), *Psychology of sustainable development* (pp. 61–78). Springer US.

Stone, S. B., Myers, S. S., & Golden, C. D. (2018). Cross-cutting principles for planetary health education. *The Lancet Planetary Health*, *2*(5), e192–e193. https://doi.org/10.1016/S2542-5196(18)30022-6

Tilleczek, K. C., Terry, M., MacDonald, D., Orbinski, J., & Stinson, J. (2023). Towards Youth-Centred Planetary Health Education. *Challenges*, *14*(1), 3. https://doi.org/10.3390/challe14010003

Watts, J. (2022). Healing the Amazon. *The Lancet*, *399*(10337), 1767–1768. https://doi.org/10.1016/S0140-6736(22)00820-0

Whitmee, S., Haines, A., Beyrer, C., Boltz, F., Capon, A. G., de Souza Dias, B. F., Ezeh, A., Frumkin, H., Gong, P., Head P., Horton, R., Mace, G. M., Marten, R., Myers, S. S., Nishtar, S., Osofsky, S. A., Pattanayak, S. K., Jongsiri, M. J., Romanelli, C., Soucat, A., Vega, J., & Yach, D. (2015). Safeguarding human health in the Anthropocene epoch: report of The Rockefeller Foundation–Lancet Commission on planetary health. *The Lancet*, *386*(10007), 1973–2028. https://doi.org/10.1016/S0140-6736(15)60901-1

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