Fake news about the environment: How Brazilian, Colombian, and Mexican science teachers react

Heslley Machado Silva[1], Gonzalo Peñaloza[2], Paula Cardoso[3], Graça Carvalho[4]

[1]State University of Minas Gerais and University Center of Formiga (Brazil). [2]Center for Research and Advanced Studies of the IPN, Monterrey, México. [3]University of Minho, Braga, Portugal). [4]University of Minho, Braga, Portugal.

Abstract: The dissemination of false scientific information through the Internet and social networks is a serious global phenomenon, generating changes in attitudes and behaviours concerning issues like the environment, public health, and public policies, among others. Teachers play a crucial role in combating misinformation and fostering critical thinking among students, families and society. Understanding how teachers perceive misinformation and establishing validity criteria of information sources is key to improving critical thinking teaching. This study aimed to understand how science teachers perceive fake environmental news in Brazil, Colombia, and Mexico. A questionnaire was applied to a sample of more than 50 science teachers in each country. It asked about social media networking habits and views on three provocative environmental questions: climate change, global warming, and the Amazonia devastation. Teachers mostly disagreed with such provocative questions; however, Brazilians showed less disagreement against those provocative questions. They also tend to deny that Amazonia is being destroyed. Data showed that scientific denialism diffusion was successful in Brazil, even among those responsible for children's scientific education. These Brazilian, Colombian, and Mexican teachers seek scientific information mainly on the Internet and social networks, which may cause fake news vulnerability. Therefore, teachers must have media education to help identify truthful digital information.

Keywords: fake news, environment, climate change, science teachers.

Introduction

The environmental issue is on the agenda of society's concern on a global scale (Thangavel et al., 2016); the scope of this issue should overcome any educational or ideological barriers and be at the centre of any public policy (Summers et al., 2001). The effects of climate change are a reality, the examples are evident, and science is accumulating data and evidence of this ongoing phenomenon (Thompson, 2010). However, despite the constant warnings from agencies, institutions, and researchers dedicated to the subject, there is still some difficulty in making this issue reach the common citizens (Robelia et al., 2012) and some political leaders (Jones et al., 2005), which causes a delay in the required measures to be taken.

Parallel to this concern, another ongoing phenomenon strongly impacts society: the disseminating of fake news through the Internet, especially by social networks (Allcott et al., 2019; Lazer et al., 2018). This tendency has

gained relevance because most people are no longer informed through traditional ways of obtaining knowledge, such as books, printed newspapers, TV news, magazines and articles, using almost exclusively social media (Brumfiel, 2009). Unfortunately, these media, Internet and social networks, are notably vulnerable to the spread of so-called Fake News, including environmental issues (Author, 2021). This global tendency has affected Latin America, particularly during and over the COVID-19 pandemic (Ceron et al., 2021).

Groups with diverse intentional interests take advantage of this vulnerability to spread disinformation to influence society (Obadă et al., 2022) and sometimes its leaders. Avoiding those relevant issues from being approached with scientific criteria based on scientific expertise and evidence. Several themes like health, vaccines, and the environment have been explored, consistently with harmful impacts on society, which should provoke more interest from the academic field (Ha et al., 2021). Just consider the example of the worldwide decline in vaccination and the return of previously controlled diseases, demonstrating that the anti-vaccine movement has exploited this mechanism to spread disinformation relatively efficiently (Chiou et al., 2018). Importantly, this is happening at the same time that the intense use of smartphones has become an almost pathological process, compared to addiction to powerful drugs, causing its users to devote hours daily of constant consultation and interaction (D'Arienzo et al., 2019). This lifestyle (Duradoni et al., 2020) has reverberated even in understanding science and the media, creating a generally new way of interpreting information in which algorithms dictate what the individual receives as news, putting him or her in a cycle of misinformation that is difficult to break.

The field of education is not immune to the tendency described above. Schools and research institutes seek to understand how this misinformation impacts formal education and the classroom learning dynamics (Rosenzweig, 2017). It is necessary to measure this impact as students reveal a much greater interest in the screens of their smartphones, devoting most of their time to these media, emphasising once again that it has become an addiction that dominates their daily lives, even in the classroom (Author, 2020). Moreover, not only are students immersed in this new environment of misinformation, but also teachers are, with a decline in searching for traditional ways of getting informed scientifically; in contrast, they frequently use the Internet and social networks for this purpose (Nelson, 1987). Therefore, it is urgent to dimension how this process occurs among teachers, how it impacts their knowledge acquisition and transmission, and how it reaches their classrooms (Chen et al., 2014; LaGarde et al., 2018).

Science teachers in the early grades are the teachers category which deserves special attention in this modern society because they are the ones who first teach science to young students, where they may reverberate, positively or negatively, about scientific knowledge (Lederman, 2014; Moutinho et al., 2015). Therefore, it is urgent to understand how these professionals deal with these new forms of dissemination of information or misinformation (Allchin, 2018). How does these professionals' training influence their interaction with social media (Cherner et al., 2019)? What is their access to quality information? How does it impact their teaching of science to children? These and other questions emerge when seeking to

improve scientific education (and literacy) in a social environment marked by misinformation.

Furthermore, climate change is currently a fundamental theme for environmental education science classes(Walsh et al., 2014). Therefore, it is necessary to find ways for the environmental topic to reach science teachers and students so that this knowledge can spread changes in attitudes towards the topic (Karpudewan et al., 2015) and make them less vulnerable to the phenomenon of false news about the environmental issue. Unfortunately, in the context of scientific disinformation, this theme has been subject to great dissemination of denying global warming and forest destruction (Pawar et al., 2015), for example. The present work aims to know how a sample of Brazilian, Colombian, and Mexican science teachers perceive and deal with issues that permeate this process of misinformation concerning some of the most frequent Fake News about the environment.

Theoretical framework

Misinformation and disinformation have historically been used to manipulate the population, and it can be said that they have been inherent to political practice (Muñiz-Velázquez, 2023). As the media have become more agile and information has flowed faster and almost instantaneously, it has become a field of permanent ideological disputes. Using information for specific purposes is currently an efficient and fast means of interference in people's perceptions, decisions and behaviours, allowing for guiding many events according to political, economic and ideological interests (Rodríguez-Ferrandiz, 2023). A great precision must be made between misinformation and disinformation. Misinformation is defined as inaccurate information shared unconsciously and without the intention to manipulate behaviour. Disinformation is defined as false information shared to influence individual and collective decisions and practices (Muhammed & Mathew, 2022).

In this framework, fake news is a kind of disinformation, defined as "fictitious information presented to the public under the guise of it being factual information, with the intention to mislead or misinform the reader." (Chong & Choy, 2020, p.1). Other authors point out that fake news "as referring to viral posts based on fictitious accounts made to look like news reports" (Tandoc et al., 2018, p. 138).

It is crucial to establish precise criteria to classify "fake news" to identify them in order to refute them. For this reason, taxonomies have been developed to help characterise them (Chong & Choy, 2020). In general terms, it is about identifying the features that define fake news, considering the nature of their statements and semantic structures. In this way, it could be easier to take actions such as training critical thinking skills so that people can question misinformation and develop concrete actions so that fake news is identified promptly on social networks.

Fake news circulates through different media and around various topics, affecting people's behaviour and decisions. For example, effects have been reported on the perception and practices of people concerning diseases such as cancer or AIDS, as well as vaccination (Ali, 2022), a trend that became very evident during the COVID-19 pandemic (Anas et al., 2023). As a result of disinformation and misinformation, it has been found that they generate

social reactions such as xenophobia and the violation of the human rights of vulnerable communities (Ali, 2022) and individuals with psychological disorders (Bansal, 2022). Misinformation and disinformation have clear effects on public health behaviour. For example, Barua's (2022, p. 16) study in Bangladesh found that "health beliefs about the COVID-19 behavioural responses, are significantly and positively influenced by the conspiracy theories and religious misinformation".

How fake news circulates differs due to conditions such as political positions (Hameleers & Brosius, 2022). The particular political context means that certain ideas or messages transmitted through social networks are more or less disseminated and accepted. For example, within the framework of political campaigns, messages are often circulated to be associated with one of the contenders, even though they are not really part of their proposals or perspectives. It intends to manipulate public perceptions of a given political faction.

Fake news is constituted as such to the extent that the audience receives it and perceives it as accurate and gives them legitimacy. Thus, fake news is co-constructed (Tandoc et al., 2018). It highlights the importance of knowing the audiences and differentiating them since specific groups cannot legitimise certain information and, thus, do not turn it into fake news. In this sense, knowing how science teachers negotiate, exchange and share information is essential. Indeed, various studies denote the importance of knowing the various social sectors and population groups to understand their validity criteria and the elements that configure them (Barua, 2022).

Information is a right

It has been postulated that information is a right, without which the existence of democracy and the exercise of citizenship are not possible. Thus, the relevance of creating effective and timely mechanisms so that people can identify and validate information, even before reproducing it, has been highlighted. For instance, misinformation and disinformation around COVID-19 led to counterproductive collective and individual behaviours in stopping waves of infections (Hameleers et al., 2020). In this context, the absence of agile and accessible mechanisms to verify information and the formation of criteria in people to identify falsehoods and to decide what is shared with others becomes evident. In the case of the environment, fake news has distorted the environmental crisis, giving the false idea that it is temporary and not caused by human activity.

One of the alternatives to fighting against fake news is to expand Media Literacy, which implies "the ability to pose critical questions at those messages with the dual purpose of understanding the entities' goal(s) for transmitting them and their potential impact on individuals, society, and the environment." (Cherner & Curry, 2019, p. 2). In this sense, the role of teachers is critical to "mediating function in knowledge construction and for their capacity to engage students in a reasoned and ethical use of information, and possibly in a position to resist misinformation and fake news." (Maury & Gatti, 2022, pp. 8-9). The management of information sources, the decisions about its dissemination and the construction of reliability criteria imply developing appropriate educational processes for an effective media literacy education.

Methods

Participants

The present study is based on cross-sectional data from a non-probabilistic sample of 161 science teachers from three countries: Brazil (n=52), Colombia (n=51) and Mexico (n=58). The teachers were aged between 21 and 63 years (M=37.8, SD=9.5).

The inclusion criterion in this study was teachers teaching science in the early grades of elementary school.

The choice of the three countries (Brazil, Colombia and Mexico) was made for the convenience and ease of access by the group of researchers. Also, these three countries, despite being on the same continent, have unique cultural characteristics in their habits and face different educational issues, even though they have in common difficulties concerning science education (Martínez Rizo, 2006; Vasquez-Anaya et al., 2022; Villar et al., 2016).

Regarding the participants' teaching practice, the mean was 9.8 (SD=8.3), with more than half having more than seven years of professional teaching experience. Of the total sample, most teachers (55.3%) had a degree in Biology, 15.5% in Pedagogy, 15.5% in Chemistry, 3.7% in Physics, and 10% in other areas. They were teaching mainly in public schools (60.8%), private schools (31.7%), and both public and private (7.5%).

Procedures and research instruments

From June to September 2022, science teachers from Brazil, Colombia and Mexico answered an online questionnaire (questionnaires took approximately 20 minutes to respond).

The questionnaire used in this research was designed to capture how science teachers take a position on fake science news that is currently being spread. The main topics covered in the questionnaire were issues on the COVID-19 pandemic, vaccines, the environment, and conspiracy theories. In addition, the questionnaire sought to understand the teachers' habits regarding social networks and the search for information and knowledge by these professionals. It is recognised that there are limitations in using this type of research instrument; however, it is considered a starting point for a first analysis of the issues addressed, which will be the basis for other future investigations, combining other research methodologies.

The online survey to which the teachers responded comprised 21 questions and a set of biographical and professional data. The 21 questions were distributed in two sections:

i) Science teachers' habits regarding social media use and ways of obtaining knowledge (11 questions);

ii) Teachers' level of agreement with fake news that deals with relevant and frequent topics in the universe of misinformation, such as vaccines, COVID-19, environment, and reliability in science (10 questions).

For this paper, we highlighted questions related to the environmental theme from the second section (ii), precisely three about climate change fake news. These questions or, more appropriately, these provocations, to which teachers had to express their level of agreement were the following:

- "The idea that the climate is changing can be false, or have no relation to human action, being a natural phenomenon";
- "There is not enough evidence to confirm that global warming is occurring";
- "The issue of deforestation in the Amazonia is exaggerated by the media, NGOs and developed countries".

The first question doubts the occurrence of climate change, something proven by a series of scientific evidence (Masson-Delmotte et al., 2021). It also assesses that if this phenomenon occurs, it could be natural and, therefore, unrelated to human actions (Wells et al., 2011), approaches that are very common on the Internet and social networks today.

The second question overlaps somehow with the first one about climate change; However, it cuts about global warming, because when we have cold waves in countries, it is common for social media to raise doubts about the veracity of the rise in global temperature (Nordhaus, 2012). These untruths rule out the observation that what is increasing are the climatic extremes and that the average temperature in the world has increased in recent years; they tend to continue happening (Planton et al., 2008). Furthermore, this dissemination discards all the data produced in recent decades by science, which proves this increase in temperature in the world as a whole (Kerr, 1989).

The third provocation suggests a distortion in the news about deforestation in the Amazon Forest, minimising this problem (Pinheiro, n.d.). It also indicates that hidden interests are involved in this kind of disclosure, disregarding all credible data involving research and preservation institutes, satellite images and other sources (Kirby et al., 2006).

The response options to these questions were Likert-type scale format with five alternatives: *Strongly agree; Agree; No opinion; Disagrees; Strongly disagrees.*

The previous validation of the questionnaire model showed a Cronbach's alpha value of 0.868, reflecting a good internal consistency.

Data analysis

Descriptive statistics were first used for data analysis to characterise the sample and the variables under study.

Next, the non-parametric Kruskal-Wallis test was used to evaluate to what extent the fact that the teaching activity is developed in a given country (Brazil, Colombia and Mexico), which significantly influenced the level of teachers' agreement with some of the most frequent fake news about the environment. Given the rejection of the null hypothesis in light of the Kruskal-Wallis test, the Dunn test was used for multiple comparisons. All tests applied the type I error probability (α) of 0.05 (Marôco, 2018). The data were analysed using IBM SPSS (Statistical Package for the Social Sciences - version 28).

Results and discussion

Overall, the results showed that science teachers in all three countries refute these statements about the environment and climate change, demonstrating that these professionals can constitute a barrier to the spread of Fake News about the environment (Allchin, 2018) and promote scientific knowledge about the subject (Davis et al., 2006). However, Brazilian teachers were the least likely to disagree with the statements strongly that can reverberate in the quality and outcome of science classes, which has repercussions on the knowledge acquired by the students (Leite et al., 2021). As teachers in all three countries also indicated that they seek knowledge from social networks and the Internet rather than the more conventional media and apparently more immune to Fake News, such as newspapers and magazines, these professionals do not seem impacted by this type of misinformation, at least concerning the topic of climate change.

Is it true that the climate is changing?

The first question/provocation ("The idea that the climate is changing can be false or have no relation to human action, being a natural phenomenon") analysed the possible falsity of the climate change phenomenon, suggesting that it could be a natural phenomenon unrelated to human action (Figure 1). It does not say that climate change is an ongoing process, that the effects are already being felt, and that it is accelerating. However, the evidence is countless, intense, and has a major impact on countries, the economy, health, and the availability of resources; in short, on people's lives (Mirza, 2003).

In general, the three countries' science teachers strongly disagreed with the statement that climate change is false or that it would only be a natural phenomenon unrelated to human action. However, some different patterns of responses emerged: Mexican teachers were the most strongly opposed to this question (81%); Colombian teachers had an intermediate position (74%); and Brazilian teachers were the less refractory (52%) to this statement (Figure 1).

The inferential analysis validated the hypothesis that the country where the teaching activity is developed had a statistically significant effect ($H(2)=14.828$; $p<0.001$; $n=161$) on the level of agreement of teachers with the question/provocation of Figure 1. According to Dunn's test for multiple comparisons, it can be concluded that teachers from Brazil present a significantly different distribution than teachers from Colombia ($p=0.011$) and Mexico ($p<0.001$), with teachers from Brazil presenting a lower level of disagreement. These results show that this is a problematic issue, particularly in Brazil.

Indeed, the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) created the Intergovernmental Panel on Climate Change (IPCC) in 1988 to provide policymakers with scientific data and information about climate change, its progress, implications, and risks ahead. This panel was also designed to propose actions to adapt to these changes and possible forms of mitigation. In 2022, the IPCC had 195 country members. This panel has been updating the climate change state of the art,

seeking consensus in the scientific community, and indicating research needs in the area.

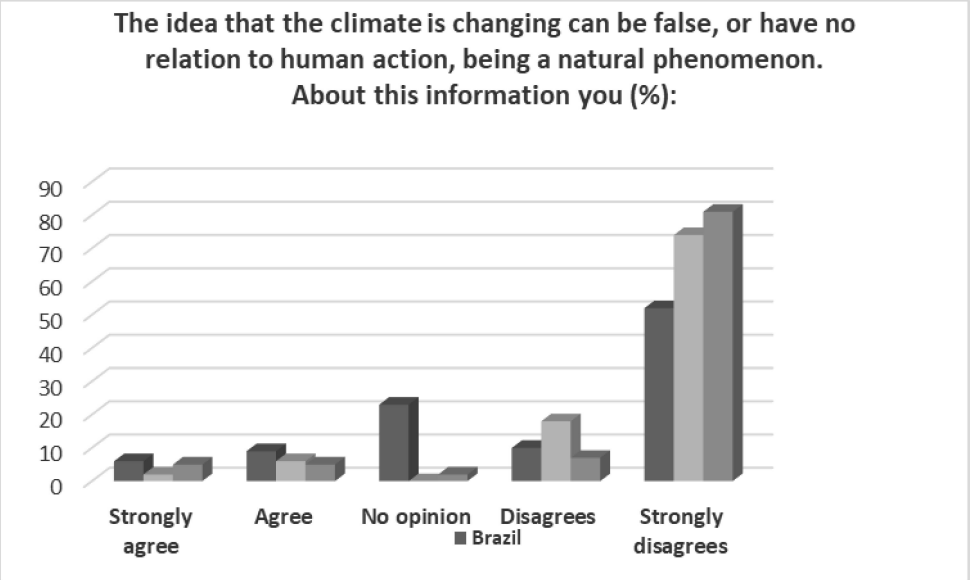

Figure 1 - Science Teachers' views on the falsity of the climate change phenomenon in Brazil, Colombia, and Mexico.

The IPCC's frequent reports have been an essential source of climate change clear scientific information, resulting in various treaties, such as the Kyoto Treaty (Böhringer, 2003) and Paris (Klein et al., 2017), that set goals to mitigate human actions that influence climate change. However, some people and governments insist on trying to deny climate change. Thus, it is urgent to seek ways to combat Fake News and respective conspiracy theories.

Several fake news stories supported the elaboration of this question to be applied to the science teachers of these three countries. Among them is the one that states the Sun would be the evident entity responsible for climate change because if there is a warming climate, it is natural that the Sun is responsible for it (Singer, 2006). Another fake news story supporting this question's formulation says that humans produce minimal carbon dioxide (CO_2) and, therefore, could not contribute to such a widespread phenomenon of global reach (Treen et al., 2020). These Fake News demonstrate a denialists' very successful strategy: to use part of valid scientific information and produce edible and true amalgam, especially for most of the population.

The level of adherence to the phenomenon of Fake News about the environment has been perceived in the Brazilian population, especially regarding climate change (Author, 2022). The data show that teachers are not immune to this movement of society. Besides being the ones who disagree less strongly, they are the ones who have the highest number of individuals who have no opinion on the subject. As it is a qualified sample with higher education and who work in the classroom with environmental issues provided for in the science curriculum, one would expect these professionals to be convinced about the occurrence of climate change. However, despite all the scientific evidence (Bernstein, 2013), 23% do not position themselves on the issue. Therefore, one should ask why these

teachers are not taking a correct scientific position. Why are they not able to build this conceptualisation?

Instead of whether the climate changes are occurring, would not the discussion be about how they are occurring? (Thuiller, 2007) With what impact? What are we doing to accelerate it? What can be done to mitigate it? Meanwhile, almost a quarter of the science teachers surveyed in Brazil have no opinion on whether climate change is occurring. The important question is how these teachers deal with this topic in the classroom (Walsh et al., 2014). How do they get informed or misinformed? Why can't they formulate an idea based on evidence on research on this issue (Nation et al., 2021)?

It is relevant to point out that Brazilian teachers indicated that they are more frequently informed via the Internet and social networks, to the detriment of other more traditional sources of information, and less vulnerable to Fake News. It is worth noting that this issue of the source of information via the Internet also occurs among teachers in other countries.

Is global warming a fallacy?

Regarding another pertinent theme, the non-occurrence of global warming, the teachers from the three countries disagreed with the statement: *"There is not enough evidence to confirm that global warming is occurring"* (Figure 2). Again, the Mexican science teachers were the most forceful in refuting the premise of the question, followed by the Colombians and the Brazilians, who were less intense in this rejection (Figure 2).

The inferential analysis also validated the hypothesis that the country where the teaching activity is developed had a statistically significant effect ($H(2)=23.361$; $p<0.001$; $n=161$) on the level of agreement of teachers with the question/provocation of Figure 2. The multiple comparisons carried out according to Dunn's test showed that teachers in Brazil had a significantly different distribution than teachers in Colombia ($p<0.001$) and Mexico ($p<0.001$), with teachers in Brazil showing a lower level of disagreement. Again, these results show that this is a problematic issue, particularly in Brazil.

From a large number of data, it is clear that this phenomenon of global warming is occurring (Jozefat, 2015). The question that emerges is how fake news found space in the media and the perception of so many people (Paltridge, 2010).

Firstly, climate change is not a uniform phenomenon; there are extreme weather events (Beniston et al., 2004), such as increased rainfall and, as a consequence, increased flooding (Bronstert, 2003); harshest droughts (Mahato, 2014); more intense winters and more violent storms (Brooks, 2013). The occurrence of very harsh winters, reaching areas that generally do not face cold weather, has been used by denialist groups to spread the idea that global warming is a fallacy (Leroux, 2005).

A notable example occurred in recent years in the US when too low temperatures hit the south of that country, and President Trump asked where global warming was and doubted the truth of the global warming theory (Eilperin, 2016). This vision marked the entire negationist policy concerning this environmental issue (Davenport et al., 2019), linked to the lack of

understanding of the overall phenomenon and the complex and interrelated variables (Ison, 2017). Then, it has been exploited by politicians and unscrupulous people who want to benefit from this misconception diffusion (Lewandowsky, 2021; Uscinski et al., 2017).

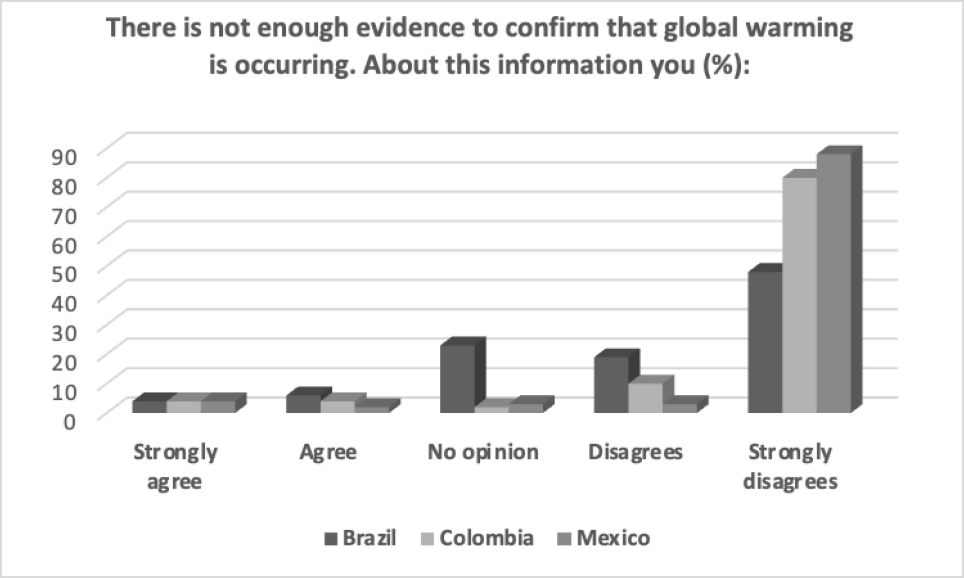

Figure 2 - Science Teachers' views on the falsity of global warming in Brazil, Colombia, and Mexico.

One of the most frequent expedients used by those who spread Fake News is the fusion of real facts, such as intense cold waves, with a lie that warming is not occurring, which could explain the adherence to this type of news and discourse (Kolmes, 2011; Treen et al., 2020). In addition, these societies that are permeated by fake news, such as in the US and Brazil, can help explain the less disagreement with global warming shown by Brazilian teachers (Figure 2). Indeed, Brazilian authorities have reinforced the dissemination of Fake News, such as Bolsonaro's government (Ricard et al., 2020).

Another fact that draws attention among Brazilian teachers, compared to their Colombian and Mexican colleagues, concerns the relatively high percentage of Brazilian teachers with no opinion about this urgent environmental issue. One must emphasise that those who do not formulate an opinion may not have built a framework of data to perceive global warming and will be more vulnerable to the influence of fake news and may formulate wrong ideas. This situation is more acute in societies such as the Brazilian one for the above reasons. It is also serious due to the science teachers' ascendancy over the students and potentially even the families and the community.

Is there an exaggeration regarding the deforestation of the Amazon?

Most science teachers in the three countries investigated refuted the suggested question: *"The issue of deforestation in the Amazonia is exaggerated by the media, NGOs, and developed countries"* (Figure 3). However, some differences emerged. Regarding this provocation, Colombian teachers were more emphatic in their denial, followed by Mexican teachers, and again, Brazilian teachers refuted with less intensity. A significant

proportion of the Brazilian teachers (12%) agreed with the question, and a higher percentage (17%) had no opinion. Some Mexicans also did not give an opinion (10%), and no agreement was found among the Colombians (0% for strongly agree, Agree, and No opinion).

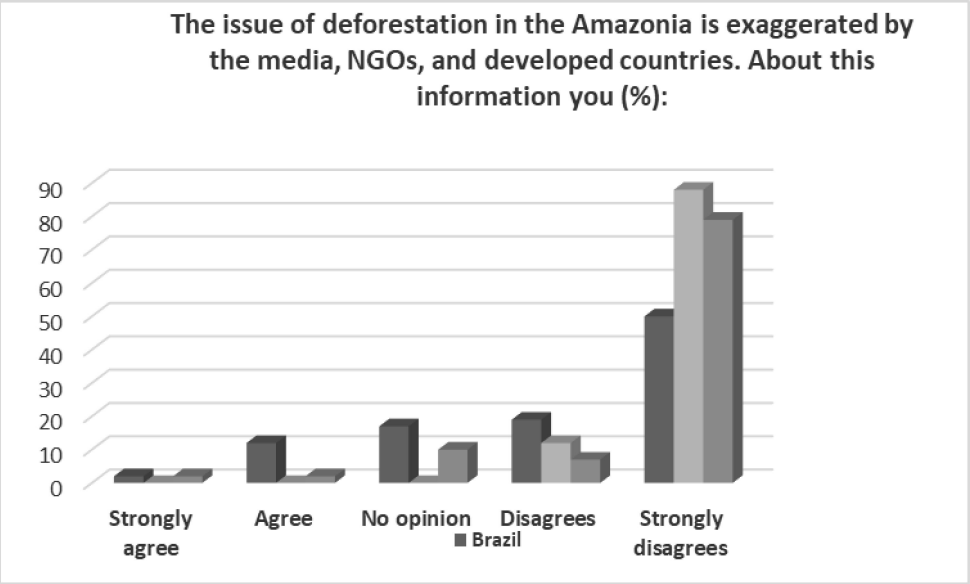

Figure 3 - Science Teachers' views on the falsity of the intensity of deforestation in the Amazon in Brazil, Colombia, and Mexico.

The inferential analysis also validated the last hypothesis that the country where the teaching activity is developed had a statistically significant effect ($H(2)=21.735$; $p<0.001$; $n=161$) on the level of agreement of teachers with the question/provocation of Figure 3. Furthermore, the multiple comparisons carried out according to Dunn's test showed that teachers in Brazil had a significantly different distribution than teachers in Colombia ($p<0.001$) and Mexico ($p<0.001$), with teachers in Brazil showing a lower level of disagreement. Once again, these results show that this is a problematic issue, particularly in Brazil.

It is interesting to discuss the reasons for these results. First, since the Brazilian teachers belong to the country that owns most of the Amazonia Forest, they would be more aware of what happens there, and therefore, the fake news discourse on the issue would be more convincing. In contrast, no Colombian teachers followed the same line, and the Amazonia region of Colombia comprises 42% of the territory of that country, so the population lives with the blessings and the woes related to the preservation and destruction of the forest (Armenteras et al., 2006), just like Brazilians also live.

Two pieces of information about the use of social networks and the dissemination of Fake News distinguish these two populations, Brazilians and Colombians, that can help elaborate the disparate results. Indeed, Brazilians are a population that uses most social networks daily and are associated with them; they also suffer intense influence from the spread of fake news, many disseminated by authorities, as during the Bolsonaro government (2019-2022) (Casarões et al., 2019). It creates an ideal environment for

disseminating conspiracy theories about Amazonia. President Bolsonaro has already been explicit in this action, with statements regarding Non-Governmental Organisations (NGOs) (Menezes et al., 2021), regarding the interests of developed countries in the riches of the Amazon, always exalting a proud patriotism that claims that the forest is Brazilian. The efficiency of extreme right-wing groups in Brazil in social networks should also be highlighted (Feres Júnior et al., 2021). In addition, the ability to penetrate Brazilian society results in great popular support by some sectors.

The teachers' answers to the third and last question suggest that they believe the media, NGOs, and the developed countries exaggerate the Amazonia deforestation issue. Their answers are based on the premise that deforestation is fake news, used as an instrument of coercion by the wealthiest countries, which have already deforested their forest reserves, and now they judge developing countries such as Brazil and Colombia, for example, about the Amazonia.

Another explanation for this exaggerated interest in the Amazonia destruction by the most developed countries is that they are trying to prevent non-developed countries, such as Brazil, from exploring their riches (gold, niobium, oil, and other minerals), supposedly existing in large quantities in Amazonia; in this way, the non-developed countries would become strong commercial rivals to developed countries.

This story has another version, also popular on the Internet, in social networks and among Brazilian nationalists, that NGOs are used so that these rich countries actually take possession of the Amazonia Forest and could later appropriate its valuable resources.

Preservation would also be an instrument for commercial competition. The financial agents and farmers of the developed countries would use the excuse of deforestation to impose restrictions and taxes on imported products and create a protection (market reserve) for agricultural, livestock and mineral products (Barbosa, 2000).

Several NGOs are active in the Amazon forest in support of local populations, using sustainable forest resources, and protecting fauna and flora, among other issues (Barbosa, 2003). However, this action is often denied on the Internet and in social networks, and several sites or groups disclose that many of these entities would be at the service of developed countries, continuing the thesis that the interest would be to prevent the progress of poorer countries. Indeed, there are several conspiracy theories about these NGOs' role, and with objectives that are far from the well-being of the local populations and the protection of the forest, denying the NGOs' preservationist character.

It is important to emphasise that there is no evidence that NGOs working in Amazonia do not have humanitarian and ecological interests, that the countries that condemn the destruction of the forest do so for commercial reasons or any other hidden interest. So, the problem of how science teachers, especially Brazilian science teachers, have been informed is evident. Indeed, Brazilian teachers generally reported getting knowledge through the Internet and social networks more frequently than through other

more credible media, such as scientific articles, books, magazines, and newspapers.

Conclusions

The refusal of most science teachers in the three countries to the three provocative questions signals a positive condition enabling a possible barrier in schools to the phenomenon of scientific misinformation in society (Keselman et al., 2021). These teachers initiate the population's contact with science, so they must get engaged in the dissemination of credible information and allow the construction of a framework of knowledge for the construction of critical thinking (Jones, 2022). In this way, the students can have some protection outside the school and help their families face this new phenomenon. On the other hand, the data demonstrated the relevance of this issue and the need to promote training and continuing education for these professionals, including media education, which allows teachers to distinguish false news on the Internet and social networks (Abd-El-Khalick, 2013). Because of teachers' social role , it is a huge problem that many teachers have doubts about such pertinent issues or do not know what opinion to give (Kind, 2014). These conditions make them vulnerable to assimilating nonsense ideas without a scientific foundation, which can compromise scientific education (and literacy) (Faintuch et al., 2022). Therefore, the work on scientific-based knowledge must be even more intense in countries where the use of social networks has been more intense and where the spread of fake news has been part of the population's everyday life.

References

Abd-El-Khalick, F. (2013). Teaching with and about nature of science, and science teacher knowledge domains. *Science & Education*, *22*, 2087–2107.

Ali, S. (2022). Combatting Against Covid-19 & Misinformation: A Systematic Review. *Human Arenas*, *5*, 337–352.

Allchin, D. (2018). Alternative Facts & Fake News. *The American Biology Teacher*, *80*(8), 631–633.

Allcott, H., Gentzkow, M., & Yu, C. (2019). Trends in the diffusion of misinformation on social media. *Research & Politics*, *6*(2), 1-8. https://doi.org/10.1177/2053168019848554

Anas, A.L., Salifu, M. & Zakaria, H.L. (2023). COVID-19 Pandemic and Vaccination Skepticism. *Human Arenas*. https://doi.org/10.1007/s42087-023-00334-w

Armenteras, D., Rudas, G., Rodriguez, N., Sua, S., & Romero, M. (2006). Patterns and causes of deforestation in the Colombian Amazon. *Ecological Indicators*, *6*(2), 353–368.

Barbosa, L. C. (2000). *The Brazilian Amazon rainforest: Global ecopolitics, development, and democracy*. University Press of America.

Barbosa, L. C. (2003). Save the rainforest! NGOs and grassroots organisations in the dialectics of Brazilian Amazonia. *International Social Science Journal*, *55*(178), 583–591.

Bansal, P. (2022). The Ravaged Psyche: Impact of the COVID-19 Pandemic on the Human Mind. *Human Arenas, 5*, 694–706.

Barua, Z. (2022). COVID-19 Misinformation on Social Media and Public's Health Behavior: Understanding the Moderating Role of Situational Motivation and Credibility Evaluations. *Human Arenas*. https://doi.org/10.1007/s42087-022-00291-w

Beniston, M., & Stephenson, D. B. (2004). Extreme climatic events and their evolution under changing climatic conditions. *Global and Planetary Change*, 44(1–4), 1–9.

Bernstein, L. (2013). *Climate change 2007*. desLibris.

Böhringer, C. (2003). The Kyoto protocol: a review and perspectives. *Oxford Review of Economic Policy*, *19*(3), 451–466.

Bronstert, A. (2003). Floods and climate change: interactions and impacts. *Risk Analysis: An International Journal*, *23*(3), 545–557.

Brooks, H. E. (2013). Severe thunderstorms and climate change. *Atmospheric Research*, *123*, 129–138.

Brumfiel, G. (2009). Supplanting the old media? Science journalism is in decline; science blogging is growing fast. But can the one replace the other. *Nature*, *458*(7236), 274–278.

Casarões, G., & Flemes, D. (2019). Brazil First, Climate Last: Bolsonaro's Foreign Policy. *GIGA Focus Lateinamerika*, *05*.

Ceron, W., Gruszynski Sanseverino, G., de-Lima-Santos, M.-F., & Quiles, M. G. (2021). COVID-19 fake news diffusion across Latin America. *Social Network Analysis and Mining*, *11*(1), 1–20.

Chen, J. A., Morris, D. B., & Mansour, N. (2014). Science Teachers' Beliefs: Perceptions of Efficacy and the Nature of Scientific Knowledge and Knowing. *Science*, *9*, 11.

Cherner, T. S., & Curry, K. (2019). Preparing pre-service teachers to teach media literacy: A response to "Fake News." *Journal of Media Literacy Education*, *11*(1), 1–31.

Chiou, L., & Tucker, C. (2018). *Fake news and advertising on social media: A study of the anti-vaccination movement*. National Bureau of Economic Research.

Chong, M., & Choy, M. (2020). An empirically supported taxonomy of misinformation. In Management Association (Ed.), *Research Anthology on Fake News, Political Warfare, and Combatting the Spread of Misinformation* (pp. 1–24). https://doi.org/10.4018/978-1-7998-7291-7.ch001

D'Arienzo, M. C., Boursier, V., & Griffiths, M. D. (2019). Addiction to social media and attachment styles: A systematic literature review. *International Journal of Mental Health and Addiction*, *17*(4), 1094–1118.

Davenport, C., & Landler, M. (2019). Trump administration hardens its attack on climate science. *New York Times*, *27*.

Davis, E. A., Petish, D., & Smithey, J. (2006). Challenges new science teachers face. *Review of Educational Research*, *76*(4), 607–651.

Duradoni, M., Innocenti, F., & Guazzini, A. (2020). Well-being and social media: A systematic review of Bergen addiction scales. *Future Internet*, *12*(2), 24.

Eilperin, J. (2016). Trump says 'nobody really knows' if climate change is real. *Washington Post*. *Retrieved*, 12.

Faintuch, J., & Faintuch, S. (2022). *Integrity of Scientific Research: Fraud, Misconduct and Fake News in the Academic, Medical and Social Environment*. Springer Nature.

Feres Júnior, J., & Gagliardi, J. (2021). Populism and the media in Brazil: The case of Jair Bolsonaro. In Kohl, C., Christophe, B., Liebau, & H., Saupe, A. (Eds.), *The Politics of Authenticity and Populist Discourses* (pp. 83–104). Springer.

Ha, L., Andreu Perez, L., & Ray, R. (2021). Mapping recent development in scholarship on fake news and misinformation, 2008 to 2017: Disciplinary contribution, topics, and impact. *American Behavioral Scientist*, *65*(2), 290–315.

Hameleers, M., & Brosius, A. (2022). You Are Wrong Because I Am Right! The Perceived Causes and Ideological Biases of Misinformation Beliefs. *International Journal of Public Opinion Research*, *34*(1). https://doi.org/10.1093/ijpor/edab028

Hameleers M., van der Meer G. L. A., Brosius A. (2020). Feeling "disinformed" lowers compliance with COVID-19 guidelines: Evidence from the US, UK, Netherlands and Germany. *Harvard Kennedy School Misinformation Review*, *1*, 1–16. https://doi.org/10.37016/mr-2020-023

Ison, R. (2017). *Systems practice: How to act: In situations of uncertainty and complexity in a climate-change world*. Springer.

Jones, B. D., & Baumgartner, F. R. (2005). *The politics of attention: How government prioritizes problems*. University of Chicago Press.

Jones, C. L. (2022). *Teachers' Perceptions of Fake News and News Literacy: Integrating News Literacy into the Curriculum*. California State University, Long Beach.

Jozefat, B. (2015). Climate change and all evidences of global warming. *Climate Change*, 61–73.

Karpudewan, M., Roth, W.-M., & Abdullah, M. N. S. Bin. (2015). Enhancing primary school students' knowledge about global warming and environmental attitude using climate change activities. *International Journal of Science Education*, *37*(1), 31–54.

Kerr, R. A. (1989). The global warming is real. *Science*, *243*(4891), 603–604.

Keselman, A., Smith, C. A., Leroy, G., & Kaufman, D. R. (2021). Science Education as a Barrier against "Fake Health News." *Science| Environment| Health: Towards a Science Pedagogy of Complex Living Systems*, 225–250.

Kind, V. (2014). Science teachers' content knowledge. In H. Venkat, M. Rollnick, J. Loughran, & M. Askew (Eds.), *Exploring Mathematics and Science Teachers' Knowledge* (pp. 37–50). Routledge.

Kirby, K. R., Laurance, W. F., Albernaz, A. K., Schroth, G., Fearnside, P. M., Bergen, S., Venticinque, E. M., & Da Costa, C. (2006). The future of deforestation in the Brazilian Amazon. *Futures*, *38*(4), 432–453.

Klein, D., Carazo, M. P., Doelle, M., Bulmer, J., & Higham, A. (2017). *The Paris Agreement on climate change: Analysis and commentary*. Oxford University Press.

Kolmes, S. A. (2011). Climate change: a disinformation campaign. *Environment: Science and Policy for Sustainable Development*, *53*(4), 33–37.

LaGarde, J., & Hudgins, D. (2018). *Fact vs. fiction: Teaching critical thinking skills in the age of fake news*. International Society for Technology in Education.

Lazer, D. M. J., Baum, M. A., Benkler, Y., Berinsky, A. J., Greenhill, K. M., Menczer, F., Metzger, M. J., Nyhan, B., Pennycook, G., & Rothschild, D. (2018). The science of fake news. *Science*, *359*(6380), 1094–1096.

Lederman, N. G. (2014). Nature of science and its fundamental importance to the vision of the next generation science standards. *Science and Children*, *52*(1), 8.

Leite, A. F. M., & Bonamino, A. M. C. de. (2021). Scientific literacy: a comparative study between Brazil and Japan. *Cadernos de Pesquisa*, *51*.

Leroux, M. (2005). *Global warming—myth or reality? The erring ways of climatology*. Springer.

Lewandowsky, S. (2021). Climate change disinformation and how to combat it. *Annual Review of Public Health*, *42*, 1–21.

Mahato, A. (2014). Climate change and its impact on agriculture. *International Journal of Scientific and Research Publications*, *4*(4), 1–6.

Marôco, J. (2018). *Análise Estatística com o SPSS Statistics*. ReportNumber, Lda.

Martínez Rizo, F. (2006). PISA en América Latina: lecciones a partir de la experiencia de México de 2000 a 2006. *Revista de Educación*.

Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S. L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., & Gomis, M. I. (2021). Climate change 2021: the physical science basis. *Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2*.

Maury, Y., & Gatti, R. (2022). Teaching Information Documentation in a "Post-truth" World: A Challenge for a Critical Education. In: S. Kurbanoğlu, S. Špiranec, Y. Ünal, J. Boustany, & D. Kos, (eds) *Information Literacy in a Post-Truth Era. ECIL 2021. Communications in Computer and Information Science, vol 1533*. Springer, Cham. https://doi.org/10.1007/978-3-030-99885-1_1

Menezes, R. G., & Barbosa Jr, R. (2021). Environmental governance under Bolsonaro: dismantling institutions, curtailing participation, delegitimising opposition. *Zeitschrift Für Vergleichende Politikwissenschaft*, *15*(2), 229–247.

Mirza, M. M. Q. (2003). Climate change and extreme weather events: can developing countries adapt? *Climate Policy*, 3(3), 233–248.

Moutinho, S., Torres, J., Fernandes, I., & Vasconcelos, C. (2015). Problem-based learning and nature of science: A study with science teachers. *Procedia-Social and Behavioral Sciences*, *191*, 1871–1875.

Muhammed T, S., & Mathew, S. K. (2022). The disaster of misinformation: a review of research in social media. *International Journal of Data Science and Analytics*, *13*(4), 271–285. https://doi.org/10.1007/s41060-022-00311-6

Muñiz-velázquez, J. A. (2023). (Dis)Information Literacy: A Democratic Right and Duty of All Citizens. *Media and Communication*, *11*(2), 1–4. https://doi.org/10.17645/mac.v11i2.7029

Nation, M. T., & Feldman, A. (2021). Environmental education in the secondary science classroom: How teachers' beliefs influence their instruction of climate change. *Journal of Science Teacher Education*, *32*(5), 481–499.

Nelson, C. E. (1987). The decline of traditional media and materials in the classroom. *Educational Technology*, *27*(1), 48–49.

Nordhaus, W. D. (2012). Why the global warming skeptics are wrong. *The New York Review of Books*, *59*(5), 32–34.

Obadă, D.-R., & Dabija, D.-C. (2022). "In flow"! why do users share fake news about environmentally friendly brands on social media? *International Journal of Environmental Research and Public Health*, *19*(8), 4861.

Paltridge, G. W. (2010). *The climate caper: facts and fallacies of global warming*. Taylor Trade Publications.

Pawar, K. V, & Rothkar, R. V. (2015). Forest conservation & environmental awareness. *Procedia Earth and Planetary Science*, *11*, 212–215.

Pinheiro, D. C. (n.d.). When Fake News Accelerates the Anthropocene: The Amazon Rainforest Case (2018-2021). *Liinc Em Revista; Vol. 18 No. 1 (2022): Challenges of Social Sciences in the Anthropocene; E5927, 24*(2).

Planton, S., Déqué, M., Chauvin, F., & Terray, L. (2008). Expected impacts of climate change on extreme climate events. *Comptes Rendus Geoscience*, *340*(9–10), 564–574.

Ricard, J., & Medeiros, J. (2020). Using misinformation as a political weapon: COVID-19 and Bolsonaro in Brazil. *The Harvard Kennedy School Misinformation Review*. 10.37016/mr-2020-013

Robelia, B., & Murphy, T. (2012). What do people know about key environmental issues? A review of environmental knowledge surveys. *Environmental Education Research*, *18*(3), 299–321.

Rodríguez-Ferrándiz, R. (2023). An overview of the fake news phenomenon: From untruth-driven to post- truth-driven approaches. *Media and Communication*, *11*(2), 15–29. https://doi.org/10.17645/mac.v11i2.6315

Rosenzweig, A. (2017). Understanding and Undermining Fake News from the Classroom. *Berkeley Review of Education*, *7*(1), 105–112.

Silva, H. M. (2020). A new and serious disease arises in schools. *Journal of Education and Health Promotion*, *9*(1), 1.

Silva, H. M. (2021). Wildfires and Brazilian irrationality on social networks. *Ethics in Science and Environmental Politics*, *21*, 11–15. doi: 10.3354/esep00194

Silva, H. M. (2022). Information and misinformation about climate change: lessons from Brazil. *Ethics in Science and Environmental Politics*, *22*, 51–56.

Singer, S. F. (2006). *Unstoppable global warming: Every 1,500 years*. Rowman & Littlefield.

Summers, M., Kruger, C., & Childs, A. (2001). Understanding the science of environmental issues: Development of a subject knowledge guide for primary teacher education. *International Journal of Science Education*, *23*(1), 33–53.

Tandoc, E. C., Lim, Z. W., & Ling, R. (2018). Defining "Fake News." *Digital Journalism*, *6*(2), 137–153. https://doi.org/10.1080/21670811.2017.1360143

Thangavel, P., & Sridevi, G. (2016). *Environmental Sustainability*. Springer.

Thompson, L. G. (2010). Climate change: The evidence and our options. *The Behavior Analyst*, *33*(2), 153–170.

Thuiller, W. (2007). Climate change and the ecologist. *Nature*, *448*(7153), 550–552.

Treen, K. M. d'I, Williams, H. T. P., & O'Neill, S. J. (2020). Online misinformation about climate change. *Wiley Interdisciplinary Reviews: Climate Change*, *11*(5), e665.

Uscinski, J. E., Douglas, K., & Lewandowsky, S. (2017). Climate change conspiracy theories. In Oxford Research Encyclopedia of Climate Science. https://oxfordre.com/climatescience/view/10.1093/acrefore/9780190228620.001.0001/acrefore-9780190228620-e-328.

Vasquez-Anaya, E., Mogrovejo-Torres, L., Aliaga-Ahuanari, V., & Iraola-Real, I. (2022). Comparative Study of Academic Performance in the 2018 PISA Test in Latin America. *Trends.* In M. Botto-Tobar, O. Gómez, R. Miranda, A. Cadena S. Léon, & W. Luna-Encalada (Eds.), *Artificial Intelligence and Computer Engineering: Proceedings of ICAETT 2021*, (pp. 109–118). Springer

Villar, A., & Zoido, P. (2016). Challenges to quality and equity in educational performance for Latin America, a PISA 2012 perspective. *RELIEVE. Revista Electrónica de Investigación y Evaluación Educativa*, *22*(1), 1–10.

Walsh, E. M., & Tsurusaki, B. K. (2014). Social controversy belongs in the climate science classroom. *Nature Climate Change*, *4*(4), 259–263.

Wells, V. K., Ponting, C. A., & Peattie, K. (2011). Behaviour and climate change: Consumer perceptions of responsibility. *Journal of Marketing Management*, *27*(7–8), 808–833.