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The use of mathematics and statistics in scientific disinformation discourses in a denialist virtual community

O uso da matemática e da estatística em discursos de desinformação científica em uma comunidade virtual negacionista

El uso de las matemáticas y la estadística en discursos de desinformación científica en una comunidad virtual negacionista

L'utilisation des mathématiques et des statistiques dans les discours de désinformation scientifique au sein d'une communauté virtuelle négationniste

Gabriela Fasolo Pivaro[1]
Federal University of Ouro Preto
PhD in Science and Mathematics Education
https://orcid.org/0000-0002-7892-7362

Steve da Silva Vicentim[2]
Federal University of Cariri
PhD in Mathematic
https://orcid.org/0009-0005-4867-9694

Gildo Girotto Júnior[3]
State University of Campinas
PhD in Chemistry Education
https://orcid.org/0000-0001-9933-100X

Abstract

We know that the proliferation of disinformation on social networks has become a social problem, both fueling and being fueled by science denial discourses in ideological communities. To analyze how disinformation and science denial discourses appropriate mathematical and statistical ideas and concepts to prove their points of view, we conducted a virtual ethnography on the social network X (formerly Twitter) within a community of users commonly associated with denialist discourses as a case study to consider specific strategies for mathematical and statistical literacy. We systematically followed the community for eight months, reflecting on users' posts and interactions. We analyzed the results considering the importance of developing logic, abstraction, and communication in mathematical and statistical literacy for critical information analysis, alongside the need for political literacy. The results

[1] gabriela.pivaro@ufop.edu.br
[2] steve.vicentim@ufca.edu.br
[3] ggirotto@unicamp.br

show relationships between denialist discourses and difficulties in interpreting graphs and in understanding notions of large numbers, misconceptions about meaningful sampling, uncritical uses of percentages, and an individual quest for an alleged truth. Finally, we present examples of possible strategies in mathematics education aligned with the identified demands

Keywords: Disinformation, Social network, Scientific denialism, Mathematical literacy, Statistical literacy.

Resumen

Sabemos que la proliferación de desinformación en las redes sociales se ha convertido en un problema social, alimentando y siendo alimentada por discursos de negación de la ciencia en comunidades ideológicas. Con el objetivo de analizar cómo los discursos de desinformación y negación de la ciencia se apropian de ideas y conceptos matemáticos y estadísticos para probar sus puntos de vista, realizamos una etnografía virtual en la red social X (antiguo Twitter) dentro de una comunidad de usuarios comúnmente asociada a discursos negacionistas como estudio de caso para pensar en estrategias específicas de alfabetización matemática y estadística. Seguimos la comunidad sistemáticamente durante ocho meses, reflexionando sobre las publicaciones e interacciones de los usuarios. Analizamos los resultados considerando la importancia del desarrollo de la lógica, la abstracción y la comunicación en la alfabetización matemática y estadística para el análisis crítico de la información, junto con la necesidad de una alfabetización política. Los resultados muestran relaciones entre los discursos negacionistas y dificultades en la interpretación de gráficos, la comprensión de nociones de números grandes, conceptos erróneos sobre muestras significativas, usos acríticos de porcentajes y una búsqueda individual de los usuarios por una supuesta verdad. Finalmente, presentamos ejemplos de estrategias posibles para implementar en la educación matemática acordes con las demandas identificadas

Palabras clave: Desinformación, Red social, Negacionismo científico, Alfabetización matemática, Alfabetización estadística.

Résumé

Nous savons que la prolifération de la désinformation sur les réseaux sociaux est devenue un problème social, alimentant et étant alimentée par des discours de négation de la science dans des communautés idéologiques. Afin d'analyser comment les discours de désinformation et de négation de la science s'approprient des idées et concepts mathématiques et statistiques pour prouver leurs points de vue, nous avons réalisé une ethnographie virtuelle sur le réseau social

X (anciennement Twitter) au sein d'une communauté d'utilisateurs souvent associés à des discours négationnistes, en tant qu'étude de cas pour réfléchir à des stratégies spécifiques d'éducation aux mathématiques et aux statistiques. Nous avons suivi cette communauté systématiquement pendant huit mois, en réfléchissant aux publications et interactions des utilisateurs. Nous avons analysé les résultats en tenant compte de l'importance du développement de la logique, de l'abstraction et de la communication dans l'éducation mathématique et statistique pour une analyse critique des informations, ainsi que de la nécessité d'une éducation politique. Les résultats montrent des liens entre les discours négationnistes et des difficultés dans l'interprétation des graphiques, la compréhension des grandes quantités, des idées fausses sur les échantillonnages significatifs, des usages non critiques des pourcentages et une quête individuelle des utilisateurs d'une prétendue vérité. Enfin, nous présentons des exemples de stratégies possibles à mettre en œuvre dans l'éducation mathématique, en réponse aux besoins identifiés.

Mots-clés : Désinformation, Réseau social, Négationnisme scientifique, Éducation mathématique, Éducation statistique.

Resumo

Sabemos que a proliferação de desinformação nas redes sociais tem se tornado um problema social, alimentando e sendo alimentado por discursos de negação da ciência em comunidades ideológicas. Com o objetivo de analisar de que forma discursos de desinformação e negação da ciência se apropriam de ideias e conceitos matemáticos e estatísticos para provar seus pontos de vista, realizamos uma etnografia virtual na rede social X (antigo Twitter) em uma comunidade de usuários comumente associados a discursos negacionistas como estudo de caso para se pensar em estratégias específicas de letramento matemático e estatístico. Acompanhamos a comunidade sistematicamente por oito meses, refletindo sobre as publicações e interações dos usuários. Analisamos os resultados considerando a importância do desenvolvimento da lógica, abstração e comunicação no letramento matemático e estatístico para a análise crítica de informações, juntamente com a necessidade de um letramento político. Os resultados mostram relações entre discursos negacionistas e dificuldades em interpretação de gráficos e em noções de grandes números, noções equivocadas sobre amostragem significativa, usos acríticos de porcentagens e uma busca individual dos usuários por uma suposta verdade. Por fim, apresentamos exemplos de estratégias possíveis de serem feitas na educação matemática condizentes com as demandas encontradas.

Palavras-chave: Desinformação, Rede social, Negacionismo científico, Letramento matemático, Letramento estatístico.

The use of mathematics and statistics in scientific disinformation discourses in a denialist virtual community

We are witnessing an unprecedented era regarding the massive proliferation of both information and disinformation. Although the circulation of false news and disinformation is as old as the dissemination of news itself (McIntyre, 2018), social media platforms encourage and enable an unprecedented abundance of information, which is easily spread in virtual environments. Numerous studies have aimed to understand, explain, examine and analyze the phenomenon of mass disinformation more broadly (Kapantai et al., 2021; Soares et al., 2019; Recuero et al., 2020; Recuero et al., 2021; Talwar et al., 2019; Wardle & Derakhshan, 2017; Wu et al., 2019) while also considering the strengthening of scientific denialist movements that both fuel such discourses and gain momentum from them (Araujo & Oliveira, 2020; Massarani et al., 2021; Oliveira, 2019; Oliveira et al., 2020; Pereira & Figueiroa, 2024; Sales & Pereira, 2024). Despite the lack of consensus in the literature regarding the definition and characteristics of disinformation in virtual environments, the concept adopted herein is that proposed by Wu et al. (2019), who use it as an umbrella term to refer to any false or inaccurate information, whether spread intentionally or unintentionally.

As a means of defense against and counteraction to the abundance of information that, by blending information and disinformation, leads to the widespread dissemination of misleading content, educators and researchers increasingly stress the importance of adequate literacy. This enables individuals to engage in reflection and decision-making based on developed critical reasoning, supported by scientific, mathematical, political, media and information literacy (Höttecke & Allchin, 2020; Oliveira, 2020; Pivaro, 2023; Pivaro & Girotto Jr., 2023; Souza et al., 2022; Spinelli & Santos, 2020). To integrate these different areas of literacy, we believe that critical analysis of information requires knowledge from multiple fields, as scientific disinformation circulating in virtual environments exploits people's difficulties in critically analyzing information and making accurate inferences across various domains. Authors such as Vilela and Selles (2020) and Pivaro and Girotto Jr. (2020) discuss how the rise of certain political groups has both strengthened and been strengthened by scientific denialist discourses circulating in virtual spaces, leading to the creation of identity-based communities that uncritically consume disinformation aligned with their political ideologies.

Thus, considering the influence of these political groups in virtual environments in spreading disinformation and denying science, this study aims to analyze how such discourses circulate within a politically and ideologically driven virtual community with a denialist bias.

The focus is on identifying how mathematics and statistics are used to build arguments, support viewpoints or challenge the validity of information from scientific institutions.

We carried out a virtual ethnographic search on the social media platform X (formerly Twitter) and used the collected data as a case study to explore literacy strategies that address the identified challenges. As argued by Souza et al. (2022), mathematical and statistical content with a focus on ethics and democracy is essential for developing the skills people require to connect knowledge in ways that enable critical analysis of discourse and social criticism from a political perspective, questioning power structures. Moreover, political groups aiming to distort reality benefit when readers lack a proper understanding of numerical data in context, leading to biased narratives.

In the following section, we discuss the importance of mathematical and statistical literacy in developing cognitive tools that enable critical analysis of different types of information. We also examine the implications and consequences of such literacy being inadequate, alongside the importance of political literacy. Next, we show how science denialist discourse aligns with the defense of a neoliberal system, which is intensified by far-right movements in virtual environments.

With this study, we aim to contribute to the discussion on the spread of scientific disinformation on social media. We recognize the complexity of the issue and do not intend to exhaust the topic within these pages. Instead, we focus on the importance of mathematical, statistical and political literacy as essential tools to enable individuals to critically analyze information as a means of countering the proliferation of disinformation.

Mathematical and statistical knowledge and disinformation

To consider how the level of mathematical literacy can influence users' belief in scientific disinformation discourses when they come across such content, we must first define what we understand by mathematical literacy. Thus, we understand it to be:

> An individual's capacity to formulate, employ and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals in recognizing the role that mathematics plays in the world and in making well-founded judgments and decisions as constructive, engaged and reflective citizens. (OECD, 2013, p. 25)

This definition highlights the potential of understanding and applying mathematics in various contexts and for different purposes. By emphasizing the importance of mathematical

literacy as a means of interpreting the world, we see that this understanding goes beyond mere logical abstraction and problem-solving.

It is also essential to clarify what we mean by statistical literacy. We align with Gal's (2002) discussions, which define it as involving two interconnected components: the ability to interpret and critically evaluate statistical information that includes data and arguments in different contexts; and the ability to discuss and communicate one's reactions to statistical information, along with opinions on its implications.

To further explore the elements required for the development of mathematical and statistical literacy, our discussion herein is centered on three key dimensions—abstraction, logic and communication, which comprises relevant knowledge, techniques, technologies and practices.

Abstraction is understood as the ability to interpret concepts beyond the concrete, without, however, denying or disregarding it. In this sense, concrete serves as an example of something deeper, such as a concept, behavior, underlying reality, idea etc., making the conceptualization process possible. According to Santana (2016), abstraction in mathematical and statistical literacy is essential for students to develop the ability to critically reflect on numerical data, including the capacity to manipulate abstract mathematical concepts when analyzing data, for example. In addition, Antoniassi and Dias (2022) stress that abstraction enables students to organize and communicate collected or observed information, supporting their conclusions with well-founded arguments.

Logic involves manipulating both concrete and abstract concepts, enabling individuals to make conjectures about future events and verify outcomes by examining and manipulating bivalent statements (as defined in first-order logic). Rigon and Stamberg (2023) argue that logic facilitates the development of critical, deductive and constructive thinking, serving as an important tool not only in mathematics but also in language studies and natural sciences. It is fundamental in various argumentation models, helping to structure the understanding of situations and hypotheses while ensuring coherence in establishing cause-and-effect relationships.

Beyond that,

> Logic is the art of thinking, the art of reasoning—where reasoning is thought in motion, the sequence of judgments. It is the science that deals with the operations the human mind employs in the pursuit of truth. This includes secondary operations used in reasoning, such as comparing, classifying, analyzing, synthesizing, abstracting, surmising etc. (Bianchi, 2007, p. 7)

Lastly, communication is connected to the ability to listen, understand and express oneself in relation to the identification and mastery of mathematical language. It is essential for translating reality into abstract concepts, enabling comprehension through interactive processes among participants.

As Spinelli (2011, p. 25) argues, "the interpretation of reality requires abstractions; the interpretative nature of conceptual knowledge originates from the perception of an object's concrete attributes and manifests through abstractions." This illustrates how the interpretation of the concrete involves both communication and abstraction. To Spinelli's statement, we add the importance of logic in making sense of what is interpreted through communication and abstraction. By integrating these three dimensions, mathematical knowledge can be contextualized to support meaningful interpretations of the world.

According to Walichinski (2012), in education, contextualization aims to give meaning to systematic knowledge. It also serves as a form of communication that enhances mathematical and statistical learning by connecting theoretical concepts to everyday experiences, thereby enabling understanding and dialogue in technical discussions. Gal (2002) argues that understanding the context in which statistical data or information appears is essential for critical evaluation.

Recognizing the importance of working with contextualization means acknowledging the need to integrate the three dimensions discussed here. Such integration makes it possible for world interpretations to be grounded in appropriate mathematical and statistical knowledge that we consider key to the critical analysis of information. Likewise, the critical analysis of information leads to worldviews based on a solid foundation of knowledge. By incorporating contextualization into the classroom, students can be encouraged to develop skills that allow them to logically connect abstract content with real-world situations and, in doing so, learn to communicate, express and articulate these relationships effectively.

For Scolari, Bernardi and Cordenonsi (2007, p. 3), "many people have difficulty expressing their ideas in a logical and organized manner. As a result, even if they have great ideas, if they cannot clearly validate their convictions, they will not be able to sustain them." In other words, communication is essential not only for individuals to understand concrete concepts but also for them to know how to express that understanding. Like a chain reaction, when attempting to communicate an understanding of a concrete concept to another person, it is not only crucial for the communicator to interpret and convey the information accurately, but also for the recipient to have mathematical literacy to properly understand it. When there is a breakdown in communication between these links, misunderstandings about the intended

message can be replicated, and with each subsequent sharing, the misinterpretation spreads, further distorting comprehension. In this context, it becomes clear how disinformation related to mathematical concepts can appear credible or not, depending on the level of literacy of those receiving the information.

Thus, we emphasize the importance of clear communication in logic, whether in the expression of ideas or in the development of mathematical and statistical reasoning, associating concepts and arguments soundly. Additionally, as Jablonka (2003, p. 79) states, "communication through mathematical language, interpretation of statements containing quantitative arguments and critical evaluation of mathematical models are essential for emancipatory mathematical literacy in technologically advanced societies."

Given the above, it is clear that the individual dimensions should not be considered or addressed in isolation; rather, the three must be integrated, as they influence one another. This aligns with a literacy model based on investigative cycles, such as that proposed by Wild and Pfannkuch (1999).

Figure 1 presents a diagram illustrating the interrelations between the three dimensions. Each interacts with the others, forming an interconnected structure that fosters the development of mathematical and statistical literacy.

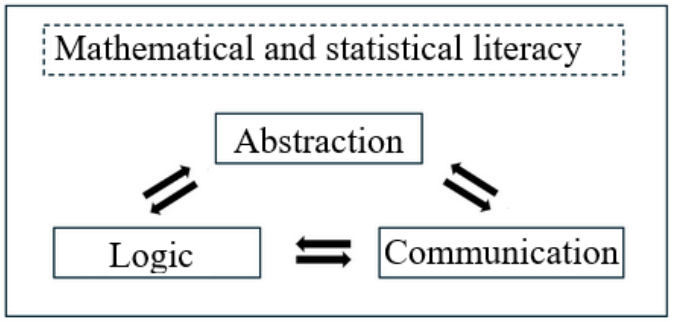

Figure 1.

Relationship between abstraction, logic and communication in mathematical and statistical literacy (designed by the authors)

When the three dimensions are not adequately developed, issues arise that affect not only academic performance but also essential practical life skills. For instance, poorly developed abstraction is linked to difficulties in generalizing concepts; poorly developed logical reasoning leads to flawed thinking and logical errors; and poorly developed communication results in an inability to articulate mathematical ideas.

In the context of disinformation, difficulties stemming from deficiencies in these literacy dimensions contribute to an inability to interpret data, recognize fallacies, verify information effectively and make informed collective decisions.

We recognize that deficits resulting from inadequacy in these three dimensions impact not only academic development but also practical life skills, such as solving everyday problems, making data-driven decisions and reasoning consistently about real-world situations. Moreover, insufficient mathematical and statistical literacy within a society can be exploited by individuals or groups to manipulate information, influence opinions and lead people to false conclusions (Huff, 1993; Seife, 2012). This occurs due to the difficulty many people face in interpreting data, understanding statistics or questioning seemingly technical arguments. Souza et al. (2022) highlight several strategies used to exploit such difficulties, which we outline below.

False numbers — whether due to miscalculations or excessively large and imprecise figures — can be used to mislead people, either downplaying an issue or exaggerating the perceived risk of a situation. This may also cause listeners to associate contexts that were not explicitly linked, even if that was the intention. By presenting numbers in this way, a narrative gains an appearance of absolute truth, which is why such strategies are frequently used in political communication.

Similarly, numbers can also be used to minimize risk and enhance the perceived reliability of information, as they can boost confidence in a claim at times of uncertainty. This strategy may be accompanied by an appeal to authority, in which the communicator relies on their career or public visibility to reinforce their argument. These tactics — leveraging numbers or the communicator's position — constitute a power struggle aimed at delivering the final word on a subject. In this regard, Souza et al. (2022) stress the importance of integrating mathematical and statistical education with a critical perspective to counter the notion that mathematics and statistics are inherently precise, exact and authoritative in addressing social issues. We further argue that mathematics and statistics should be viewed as tools that must be combined with other literacy domains to achieve a comprehensive interpretation of phenomena and situations.

The authors also highlight how data and/or variable selection, along with the improper use of the mean, are conveniently used to support specific viewpoints. We add that presenting a mean without properly accounting for dispersion and the median can distort the meaning or perception of data. Furthermore, using a restrictive sample can lead to biased and unrepresentative statistics.

Lastly, Souza et al. (2022) point to the strategy of comparing unrelated objects by establishing forced correlations with excessive data. These are all tactics used to confuse people and back arguments with mathematics.

Huff (1993) identifies additional strategies in which mathematics and statistics are used to deceive and mislead the public. They include selective data presentation, such as partially displaying graphs with incomplete contexts; appeals to complexity, using intricate techniques or equations to create an illusion of authority; reliance on non-representative samples, such as presenting the results of an opinion poll from a specific group as if they reflected a larger community's views; and manipulated graphs featuring disproportionate scales, with no axes or regular intervals.

A person struggling with the development of mathematical and statistical literacy may adopt a passive stance toward information constructed with the use of these strategies. For an active stance, critical thinking must be developed and cultivated through literacy. As Cazorla and Castro (2008) point out, statistical information permeates citizens' lives and often influences their decisions, but such information frequently contains traps that go unnoticed by individuals who lack basic mathematical and statistical knowledge. The authors further discuss how numbers convey an impression of scientific validity, impartiality and neutrality, making them effective tools in discourse to gain credibility with a lay audience that lacks the means to question or counter-argue. In this way, numbers lend an air of rationality to complex decisions.

For political emancipation and the development of critical awareness, it is essential to teach individuals how to connect the necessary skills involved in mathematical and statistical literacy (Souza, 2017). Thus, a well-balanced development of abstraction, logic and communication is key to equipping individuals with the tools to question power structures and critically analyze the information they encounter in daily life. This, in turn, enables them not only to pursue collective well-being but also to make informed individual decisions that enhance their quality of life.

Ideology and scientific denialism

In 2016, the term "post-truth" gained global prominence following events such as Donald Trump's election and the Brexit vote, both of which were marked by the widespread dissemination of false information that influenced voters. People did not seem concerned with the truthfulness of information but rather with whether it aligned with their personal beliefs (D'Ancona, 2018). The term was then defined as "circumstances in which objective facts are less influential in shaping public opinion than appeals to emotion or personal belief" (English

Oxford, 2016, online). As history shows, the connection between post-truth and political events is no coincidence but rather a consequence of decades of attacks on science, strategically carried out by neoliberal sectors to strengthen narratives of scientific denialism (McIntyre, 2018).

The historical roots of political strategies designed to cast doubt on the validity of scientific information can be traced back to the tobacco industry's actions in the 1950s (Rabin-Havt, 2016; Oreskes & Conway, 2010). In the early 1950s, numerous scientific studies began stressing the link between smoking and respiratory diseases. To prevent financial losses, various American tobacco companies joined forces to defend the industry as a whole. This defense involved creating a commission—funded by the industry itself—whose goals was to convince the public that there was no scientific proof that smoking harmed health. To this end, the commission launched newspaper advertisements that reached millions of Americans, featuring statements claiming there was no scientific consensus that smoking caused cancer and that many scientists disputed the statistical data linking cigarettes to disease. As part of their strategy, the tobacco industry assembled a specific group of so-called experts who contradicted established scientific knowledge and argued that further research was needed.

Oreskes and Conway (2010) explain some of the tricks used by the tobacco industry to cast doubt on the scientific knowledge of the time. To convince people that there was still much to consider on the issue, the industry had many (valid) questions posed to journalists, such as "Why is cancer more common in men?" or "Why does cancer develop in the lungs and not on the tongue?" or "Why are there more cancer cases in the UK than in the United States?" and so on. They took advantage of a popular yet mistaken perception of science, which failed to recognize that doubt is an inherent part of the scientific discovery process, to create the impression that research was still inconclusive and that, since much remained to be discovered, it might be too early to infer those cigarettes caused cancer.

Another strategy was to argue that science could not definitively state that smoking caused cancer, using as "evidence" the fact that not all smokers develop the disease. As Oreskes and Conway (2010) conclude, the key to the tobacco industry's success was exploiting a regular trait of science—uncertainty, which is essential for scientific progress—to undermine public confidence in scientific knowledge. The distorted idea that science is built on absolute and infallible facts weakens trust in scientific findings and fuels denialism.

We see here how the tobacco industry exploits causality to deny correlation. To discredit studies highlighting the harms of smoking, they produce biased research with misleading results by their so-called experts. In addition, they raise conditional questions that the initial studies had not yet addressed, further eroding public trust in scientific knowledge.

Today, scientific denialist groups continue to exploit the misconception that science consists of absolute truths dictated by authorities. As a result, doubting the driving force behind scientific progress—becomes a weakness in the eyes of the lay and conservative public (Vilela & Selles, 2020). Added to this are the studies by Pivaro (2023), Pivaro and Girotto Jr. (2022, 2023) and Girotto Jr. et al. (2022), who analyzed the characteristics of science denialism narratives that spread easily on social media and digital platforms. Their findings show that such narratives, considered disinformation because they contradict scientific consensus and cast doubts on knowledge-producing institutions, reflect misconceptions about the nature of science and the process of scientific construction and validation. These points reinforce the importance of scientific literacy in developing critical content analysis.

Such was the success of the tobacco industry's campaign that its strategies are replicated whenever science threatens big corporations (Oreskes & Conway, 2010). In other cases of promoting denialist discourses, this strategy has been, and continues to be, used in discussions about climate change, global warming and arms control, and has shaped debates on acid rain and the ozone layer hole (McIntyre, 2018; Oreskes & Conway, 2010; Rabin-Havt, 2016).

Pivaro and Girotto Jr. (2020) provide a comparative historical synthesis of the strategic moves of the tobacco and oil industries in casting doubt on scientific consensus among the public. Just as the tobacco industry aimed to continue selling its products and avoid million-dollar losses due to the link between smoking and respiratory diseases, there is an economic interest in denying climate change caused by the use of fossil fuels. Gastaldi (2018) argues that recognizing the relevance of climate change implies supporting government regulation and state intervention in markets, measures that are opposed to the neoliberal ideals defended by conservative hegemonic classes.

In Brazil, we can cite events that exemplify the relationship between the ideological political defense of neoliberal sectors and the discourse of climate change denial. In 2019, the then foreign minister, Ernesto Araújo, referred to concern about global warming as "climatism" in a lecture in Washington, calling it "alarmism" for political purposes (Dias, 2019). Also in 2019, the then president, Jair Bolsonaro, stated that international pressure to establish measures to contain global warming was a "commercial game" (Amorim, 2019). In the same year, the Rio de Janeiro city councilor Carlos Bolsonaro, on his X (formerly Twitter) account, questioned the existence of global warming by referencing cold days, aligning with former U.S. President Donald Trump, who has also used that social media platform to deny climate change, using the same argument (Pivaro & Girotto J., 2020).

We use climate denial as an example of political ideology behind scientific denialist movements. Not in all cases, of course, as research on belief in a flat Earth, for example, does not reflect relevant ideological political relations among those involved in the movement (McIntyre, 2021). However, such reflections highlight the importance of proper scientific and political literacy, so that individuals can make their own critical reflections and associations and identify whether there are ideological political influences in the narratives challenging scientific consensus they come across in the media.

Science has been under attack by sectors aligned with a neoliberal agenda for decades, and with the increase in political polarization, certain narratives and positions have become characteristic of a particular side of the political spectrum, where ideology prevails over science (Pivaro & Girotto Jr., 2020). As described by Vilela and Selles (2020), science denialism movements have gained strength and visibility with the popularization of the internet and the global rise of the far-right, with the strengthening of identity groups that, in virtual communities, spread and consume disinformation uncritically.

Understanding the relationship between scientific denialist narratives and the political ideology that fuels them makes it possible to examine more closely how these characteristics manifest in interactions on social media. By focusing on the discourses of people within a political ideological community commonly associated with denialist stances, we aim to understand how the credibility of institutionalized science is attacked. Therefore, this paper aims to analyze how, within the discourses of disinformation that deny science, mathematical and statistical concepts and understandings are manipulated to defend denialist positions.

Methodology

Our choice of where to collect information and data for this investigation is based on the understanding that disinformation narratives stimulate and are stimulated by denialist movements, which, in turn, are strongly related to groups with different interests. Therefore, we chose to analyze a community of supporters of former President Jair Bolsonaro on the social network X (formerly Twitter) as a case study to understand characteristics of disinformation narratives. We decided to analyze social interactions on X because this social network affords users great potential for political mobilization (Recuero, 2014; Recuero et al., 2015); the discourses of Bolsonaro and his supporters on X are related to the spread of disinformation on this platform (Soares, 2020); and the platform allows actors from different social levels to interact with each other, even if they are not personally acquainted. For current and future

research, we can also justify this choice by noting that after Elon Musk acquired X, moderation strategies for discourses on the platform were relaxed (Cardoso, 2025).

In addition to these aspects, it is noteworthy that the former president (2019-2022) was elected during a campaign marked by the extensive dissemination of false information, and he made several denialist statements during his presidency (Benites, 2018; Oliveira, 2021). Various studies from different fields have also focused on the spread of disinformation on social media among the former president's allies (Fernandes et al., 2020; Penteado et al., 2022; Seibt & Dannenberg, 2021; Silva, 2020; Soares, 2020). Although we know that disinformation narratives are not exclusive to far-right environments, we chose this community because, given their history, we were almost certain of encountering such discourses for analysis, besides being aware of the group's aim of spreading disinformation as a political strategy (Pivaro & Girotto Jr., 2020). Thus, we conducted a virtual ethnographic study (Hine, 2000, 2005, 2015), monitoring the community consistently and systematically for eight months, from December 2020 to August 2021. Four to seven times a week, we followed the community for at least one hour each time.

Ethnography is the study of a community's culture, which can be carried out in any collective environment where people interact naturally (Angrosino, 2009). We understand that the spaces shared by community members do not necessarily need to be physical, as a community is structured by social relations and the construction of common meanings (Guimarães Jr., 2005). Thus, our ethnography was carried out in a virtual environment with social interactions among members who share the same worldview, related to the constant defense and support of common ideas and individuals.

Ethnographers strive to understand the culture shared by members of a community and its meanings. To this end, they must immerse themselves deeply and lengthily in the daily life of the community being studied (Uriarte, 2012). In so-called traditional ethnographic studies, research typically lasts a year or more. In virtual environments, it is usually shorter, as social cycles occur more rapidly due to the speed of virtual exchanges (Guimarães Jr., 2020). Thus, the choice to follow the community for eight months was based on our understanding that we had already collected enough data for a deep and meaningful analysis of the shared culture.

The ethnographic perspective of this study is structured, in practical terms, in three phases: immersion in theory; time living among the community members; and writing (Uriarte, 2012). Initially, we researched theoretical frameworks on the studied topic and analyzed the community in order to integrate information about what is already known with what was being found. During the fieldwork phase (time living among the members), we kept a field diary

where we took notes on the observed interactions. To this end, we created a separate document with saved tweets, along with contextual comments about the main news of the day and our impressions about the tweet, explaining why we saved it, considering the context of the disinformation analysis. By the end, the file with the saved tweets and our comments ran to 322 pages. In the writing phase, this field diary was read and re-read in order to analyze the characteristics and categories of the narratives in a more organized manner and with a holistic view of the community. The results presented herein are a specific and expanded sample of the total findings of the study, which are available in full for readers interested in Pivaro (2023).

We created an exclusive account for this research so that the account recommendation algorithms and the content displayed would be based on an initial dataset. After creating the account, we followed Jair Bolsonaro and his sons, Carlos, Flávio and Eduardo, and then began following other accounts solely through algorithmic recommendations, using a snowballing technique (Parker et al., 2019). By the end of the research, we were following 150 accounts, all from users with public accounts. This decision was made for ethical reasons, ensuring that the analyzed content qualified as public information, meaning it could be accessed by anyone, including those without an account on X. At no point did we interact with other users; we only observed their interactions. For ethical reasons, we also anonymized the accounts of users who are not public figures.

It is important to note that though we were following 150 accounts, we had contact with many others. It is impossible to name them all, as the structure of this network enables interaction between users who do not follow each other.

Although in ethnography it is common to observe before categorizing, in this specific case, the theoretical framework indicated that we would come across narratives reflecting the community's denialist stance. Therefore, the first category in the data systematization pertains to this denialist posture. Considering the entire scope of the research, we initially focused on scientific denial. Upon analyzing the data as a whole, we noticed the frequent use of mathematics aligned with such discourses, which we highlighted as the second category of analysis. The following section features some research results involving the users' denialist stance and its relationship with scientific, mathematical and statistical knowledge. The tweets featured throughout the discussion are representative of the characteristics under analysis and were selected as examples from a set of possibilities.

Results and Discussion

Considering the historical and social context of the research, a significant part of the disinformation and comments relate to the COVID-19 pandemic. All tweet images were taken from twitter.com.

Following data reading and interpretation, two main dimensions of analysis emerged, which are discussed in more detail with data in the following sections. The first, more general, points to aspects related to denialism and disinformation, highlighting the denialist nature of the community, in alignment with other research from different fields, as mentioned in the methodology section, which studied the characteristics of the community and the narratives of Bolsonaro's followers. The results from this category reveal that the denialism is marked by an ideological tone. The second dimension focuses on the use of mathematics and statistics in disinformation discourses, aligning both with the literature that discusses how statistics are used to distort data in biased arguments and with distinct reflections on how elements of basic statistical knowledge can be manipulated to validate disinformation.

General aspects of denialism

Regarding the term "denialism," there is a shared perception that they are considered denialists by the opposing side in an apparent ideological war they believe to be fighting. However, being labeled as a denialist is a source of pride, as it shows that they are individuals who do not conform to a system of oppression and control. In Figure 2, we see a radio commentator praising "denialist" workers who are not staying home and went to work in person (in criticism of social distancing). Figure 3 features an interaction between a state representative and a follower, where a "denialist" is viewed as someone who has freed themselves from political correctness, thinks for themselves, does not believe in the "mainstream media" and considers the term a badge of honor.

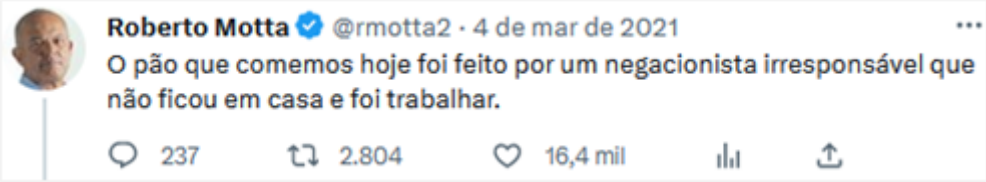

Figure 2

A radio commentator's tweet praising workers labeled as denialists for leaving home to work. Translation: The bread we eat today was made by an irresponsible denialist who didn't stay home but went to work.

Figure 3

Tweet featuring an interaction that highlights the appreciation of being called a denialist. Translation: Deputy Márcio Gualberto – Nowadays, "denialist" refers to anyone who has freed themselves from political correctness, can think for themselves, despises communo-globalism, does not believe in the so-called "mainstream media" and refuses to be chained down by petty tyrants. User's response – It has become a compliment and a badge of honor! Welcome to the converts drawn in by the good example.

Since the users do not trust the mainstream media, they adopt an independent and individual approach to seeking news, sharing their findings with other members. This community has strong bonds of unity, as seen also in the research by Cesarino (2022), where the author describes how complex feelings are mobilized within communities of Bolsonaro supporters, uniting members through emotional connections as well. The supposed discoveries they make about "others" (those against them) are treated as errors made by the other side, who were not careful enough to hide their lies. This behavior resembles conspiratorial stances (McIntyre, 2021).

In Figures 4 and 5, we see two different posts, both insinuating that China is infiltrated in various positions of power and that the users discovered this through their own investigations. In Figure 4, a user uses two images: one of a headline featuring a representative who criticizes the ideological wing of Bolsonaro's government, and another of this same deputy's Twitter account, whose biography reveals that he is the president of the Brazil-China Parliamentary Fronts. The user's post implies that the representative is a Chinese ally and, therefore, China opposes Bolsonaro's government ideology.

In Figure 5, in turn, the user suggests that China is influencing the Jovem Pan radio station because one of its editors gave interviews to a Chinese state-run media outlet when he worked for another broadcaster. The user seems to treat this fact as a surprising discovery, the result of their independent and individual research.

Figure 4

User's tweet about the alleged journalistic discovery that a Brazilian congressman is a Chinese ally. Translation: Get it now?

Figure 5.

User's tweet about the alleged journalistic discovery that China has infiltrated Rádio Jovem Pan. Translation: *HAS CHINA ENTERED JOVEM PAN? After allegations from ___, I discovered that: Humberto Candil, hired in JAN/2021 as editor-in-chief at Jovem Pan, is an old acquaintance of the Chinese state-run CCTV, to which he gave interviews while working at Band. Coincidences? #OutCandil*

Both the users in Figures 4 and 5 use publicly available information but act as if they were journalists uncovering a scoop, experiencing an "eureka" moment of discovery in which their investigations led to the perception that the enemy were lying because they weren't smart enough to cover up their trail of lies. It is through such individual search for knowledge, rejecting the knowledge shared by the system, that the users draw conclusions about various issues.

In these individual searches for the supposed truth, hidden by the mainstream media and scientific institutions, users end up reproducing some distorted views about the nature of science and the process of scientific knowledge production (Pivaro & Girotto Jr., 2022, 2023).

Similarly, these searches also reflect distorted views about concepts, uses and interpretations of mathematical and statistical results.

Mathematical and statistical aspects of denialist arguments

In Figure 6, a user reproduced an official piece of information from the World Health Organization (WHO) with a graph showing how influenza contamination rates significantly dropped throughout 2020, insinuating that there is a conspiracy to label any illness as COVID-19. This alleged inflation of death numbers supposedly occurs when hospitals report deaths not caused by COVID-19 as if they were.

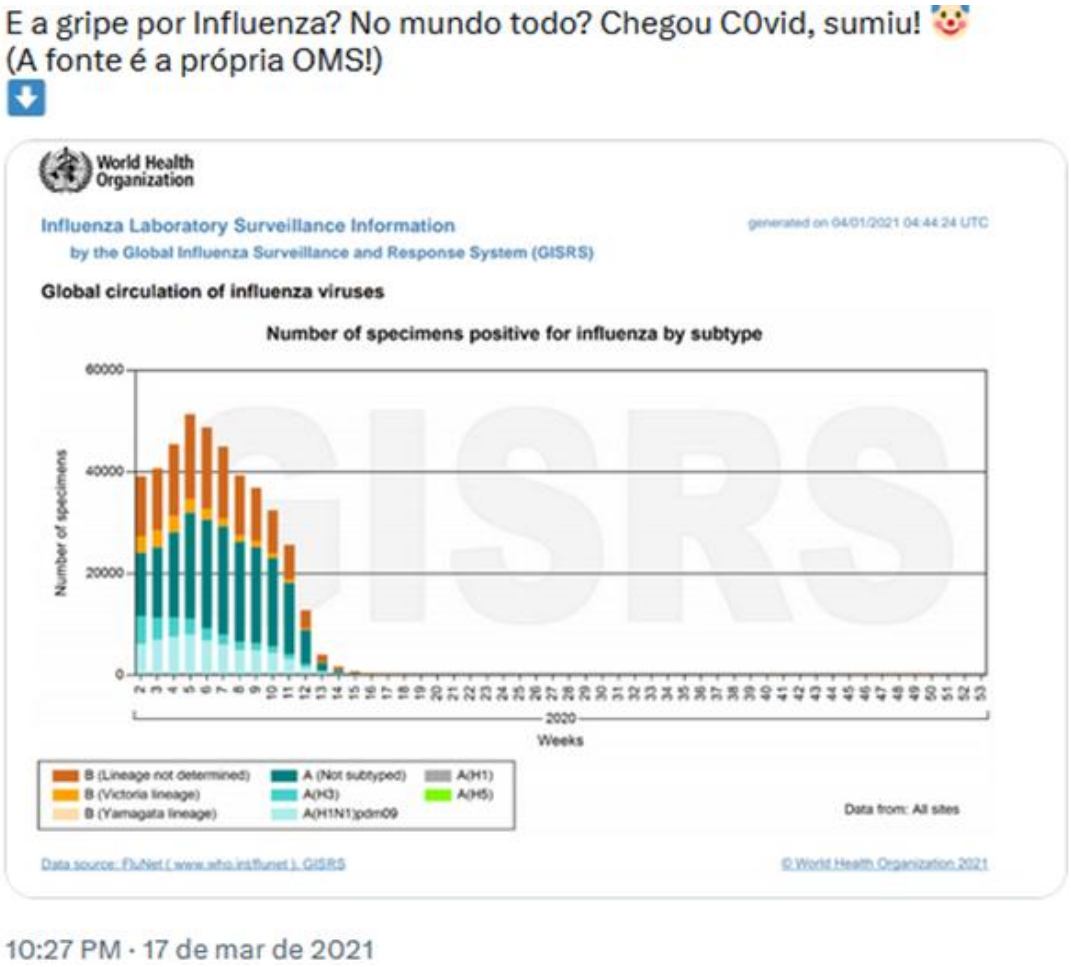

Figure 6

User's tweet showing WHO data on influenza contamination. Translation: What about Influenza flu? Worldwide? When COVID came along, it disappeared! (The source is the WHO itself!)

However, the user fails to see how their own argument can be used against their beliefs that social distancing doesn't work, as the graph they use shows how viral disease contagion decreases when protective measures are in place. The user's behavior reflects an individual search for truth, rejecting the institution that is the authority on the subject for being on the "enemy's side," using their own data to show they are wrong, denying the logic of cause and effect, where social distancing and protective measures have proven sufficient in reducing viral diseases.

We also found signs of difficulty in understanding concepts pertaining to statistics or very large numbers, evidence of which is shown in some examples presented in this paper.

Statistics involves abstract thinking as it is not possible to see all the people or situations mentioned. An extrapolation is made based on a significant and representative sample, which requires abstract thinking to be understood. Similarly, there is difficulty in understanding very large numbers because they go beyond everyday notions of quantities and are values that cannot be directly observed.

Such difficulties in understanding concepts and engaging in abstract thinking were observed on several occasions. It was common for users to reference the number of people in protests against the former president, evaluating them as small within their individual parameters, and concluding that few people were against the government. Following the same logic, but in an opposite argument, when the protest was in favor of the former president, the numbers were inflated. A case in point was a motorcycle rally held by the then-president. A rumor circulated that the protest had surpassed the Guinness World Record for the largest motorcycle gathering. Users debated that over one million motorcycles had attended the rally in São Paulo, as seen in Figure 7. They also used this supposed fact that Bolsonaro attracts large crowds in the streets to cast doubt on the electronic voting system.

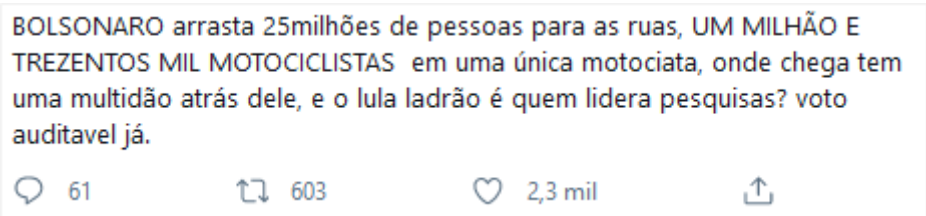

Figure 7

User's tweet about Bolsonaro's motorcycle rally gathering over a million motorcycles. Translation: BOLSONARO brings 25 million people to the streets, ONE MILLION AND THREE HUNDRED THOUSAND MOTORCYCLISTS in a single motorcycle rally, wherever he goes there's a crowd behind him, and the crook Lula is leading the polls? Auditable voting now.

One million is a very large number of motorcycles, and therefore it is difficult to measure and understand, for example, the physical space required to accommodate the motorcycles. Since it is difficult to measure, it is also easier to make mistakes, to try to manipulate or alter this estimate. The estimate of the number of participants by the São Paulo Military Police was around 12,000 people (about 100 times smaller). In Figure 7, the individual does not grasp the abstraction required to understand the magnitude of the number one million, indicating a primitive understanding of cardinality and measurability. We see that the individual cannot transition from the concrete to the abstract, as they do not recognize the difference between the two quantities (12,000 or one million and three hundred thousand) when measuring them. The possibility is either not mastering the techniques and technologies required to make such a distinction or using this very lack of understanding to influence and deceive, merely communicating a number without the proper contextualization. It is evident that, in this situation, large numbers can be used to mislead by selectively presenting data without context or reasoning for the thesis, as they cannot be perceived concretely, indicating underdeveloped abstraction, where the individual cannot detach from the concrete.

In Figure 8, we see an interaction between two users, where the first reports the death of an aunt due to COVID-19. The second asks if the aunt was elderly, had any comorbidities and was confined to her home, for, according to him, he was conducting a statistical survey. One notes that the second user does not trust the survey from official institutions, which motivates them to conduct their own survey. We can relate this behavior to that of an individual search, where the person feels capable of conducting scientific research alone, often without a method and without mastering the necessary knowledge and technologies (or even without a significant and representative sample and control groups) for such research, linking selected conditional factors in order to confirm their opinion in a specific way and raising alarms about recommendations from specialized bodies.

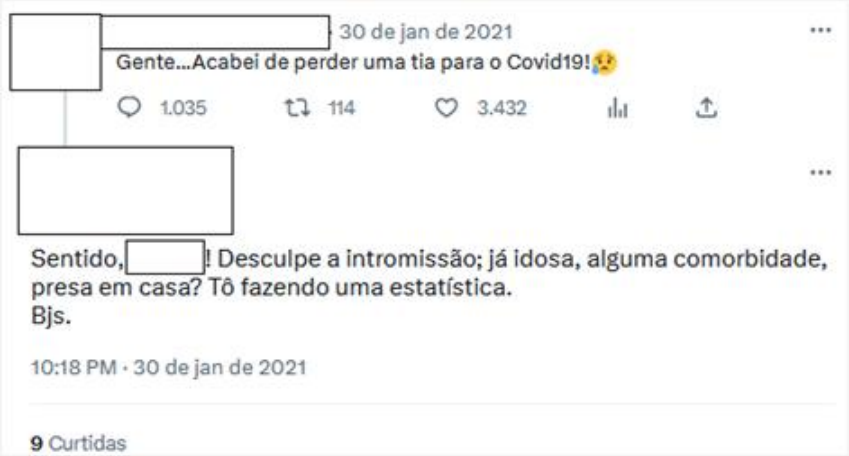

Figure 8

Interaction in which a user says they are conducting a statistical survey on COVID-19 deaths.
Translation: User – Guys... I've just lost an aunt to COVID-19.
Response from another user – My condolences, ___! Sorry to intrude; was she elderly, had any comorbidities or was she confined at home? I'm collecting statistics. Kisses.

Regarding statistical concepts, this interaction shows a certain level of understanding, insofar as the second user knows that it is necessary to collect a lot of data to draw a conclusion. But how much data would be sufficient for the sample to be statistically significant? The sample must be meaningful and represent the whole. Is it possible to obtain meaningful data by asking individuals in your Twitter feed—already biased by algorithms? These are points that should be discussed to conduct a serious statistical survey before discarding data provided by responsible or specialized public bodies such as the WHO, as if the intention were to discredit reliable sources. This might also reflect aspects related to media literacy, as the algorithmic nature of the network and the biases it generates may not be known to the user, who does not realize that, in this case, there is a methodological flaw related to sampling, for example, due to the functioning system of the X platform. This discussion underscores the importance of abstract thinking to go beyond the concrete, as statistics makes it possible to extrapolate from direct observations, using logic to make sense of statistical data in concrete terms.

Figure 9 also reveals a lack of understanding of what a meaningful sample might be. In the first-round vote for mayor of São Paulo, the initial and final percentages of the ballot count did not change much. This fact was used as an argument of fraud in the electoral system.

Although the vote took place in November 2020, this argument was repeated by the user in July 2021.

In Figure 10, a user states that 97% of the 10 million Brazilians who had COVID-19 were cured, leaving a death rate of 3%. This information was disclosed by the media in March 2021. The user and their followers who respond and comment on the tweet treat this information as something positive because a 3% death rate seems very low in comparison. However, this piece of data alone does not provide much information; for example, it is necessary to compare the mortality rate in other countries to determine whether this rate is high or low in comparison. This information, without context or a theoretical basis, is merely a number, and here we recall the importance of context for interpreting statistical data, as mentioned by Gal (2002). It is necessary to interpret the data, especially when contamination factors are not limited by geographical barriers. This information relates to a selective presentation of data, without the global context of a pandemic.

Figure 9

*Tweet about alleged fraud in the electronic voting system. Translation***:** *This is the most bizarre case in an election. A blackout at the beginning of the voting process, and by the end, the percentages remain the same. And yet, there are scoundrels who defend the integrity of the current electoral system.*

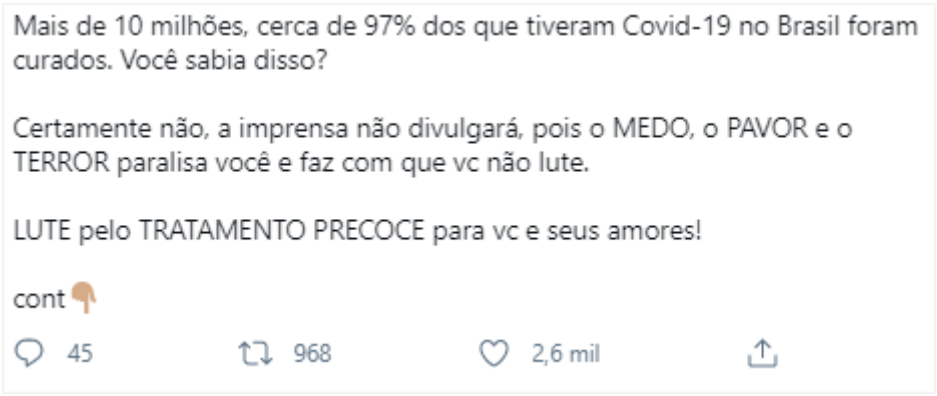

Figura 10

*Tweet about the COVID-19 recovery rate in Brazil. Translation***:** *More than 10 million, about 97% of those who had COVID-19 in Brazil have recovered. Did you know that? Certainly not, because the media won't report it. FEAR, PANIC and TERROR paralyze you and keep you from fighting. FIGHT for EARLY TREATMENT for yourself and your loved ones!*

Data commonly appear without a theoretical foundation to support them, allowing users to make interpretations that best fit what they want to defend, ignoring or discrediting both reliable sources and the complexity of the methods they use, as well as all the necessary background to understand them. Whether this is done by choice or simply due to poor literacy, users fail to differentiate between what is a fact and what is not. The defense of so-called early treatment during the COVID-19 pandemic, involving the use of medications like ivermectin and hydroxychloroquine, was strong among users of this community. Figure 11 features a tweet by a digital influencer reporting on supposed scientific studies that would prove the effectiveness of this treatment. It was fairly common to share content from the website ivmmeta.com, which compiled various studies, showing graphs and images taken out of context and without describing the methodologies that resulted in these data, which were supposedly meant to serve as evidence of the treatment's efficacy.

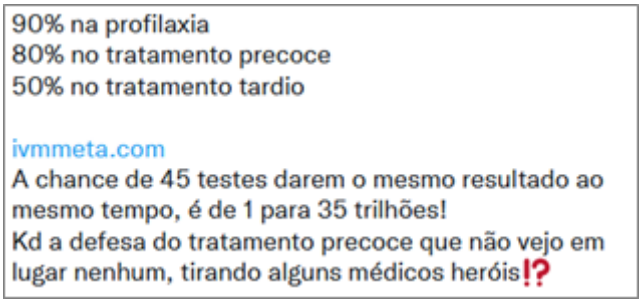

Figure 11

Tweet by an influencer and supporter of the federal government claiming that scientific studies validate early treatment and that the chance of all being wrong is one in 35 trillion. Translation: 90% in prophylaxis. 80% in early treatment. 50% in late treatment. ivmmmeta.com. The chance of 45 trials showing the same result at the same time is 1 in 35 trillion! Where is the defenders of early treatment? I don't see them anywhere except from a few heroic doctors!

We know that building scientific knowledge requires a theoretical foundation capable of articulating, predicting and describing knowledge. Simply looking at data without understanding their underlying context and who produced them it is not reliable knowledge. A second point is the user's claim that the chance of 45 tests yielding the same result is one in 35 trillion. To arrive at this result, they assumed that the chance of a scientific study finding the same result as another is 50%, in an apparent binary of "yes" or "no."

Again, we don't know the methods of the studies or their individual goals. The ivmmeta.com website presents tables and graphs without specifying what they represent. With this information (or lack thereof), it is impossible to calculate the chance of one study having the same outcome as another. Even though the user has some basic grounding in statistics — having correctly calculated the odds assuming they were indeed 50%, like flipping a coin and it landing either "heads" or "tails" — considering the probability to be 50% is merely a blind estimate, lacking an understanding of the processes involved in building and validating scientific knowledge.

Here, communication is done in a misleading way and feeds disinformation narratives, when we look both at the website itself and at the influencer's approach. On the website, data are presented without full context, showing figures like the mean, variance, median etc., which may distort the representation of their meanings, generating misleading statistics from a false interpretation (selective communication). In turn, the influencer, whose lack of expertise on the subject led them to share information from questionable sources with many people, further spreads this misinformation. Such selective communication from the website exploits people's difficulties with mathematical and statistical literacy. They struggle to interpret the information correctly because they do not understand how it is constructed, are unfamiliar with its theoretical foundations or have not fully developed abstract concepts like percentages.

Our results are related to those found in the work by Souza and Araújo (2022), in which the authors, when analyzing YouTube videos by a Bolsonaro-supporting influencer, who uses mathematical arguments to convince the public on a given topic—which is disinformation—conclude that mathematical models and discourses are used in virtual environments as a way to reinforce ideology-driven beliefs. As the authors show, users who access this content rarely reflect more deeply on the topic presented, which would require a better understanding of statistics and the ability to read and produce graphs and tables, comprehend the concept of samples and know the requirements for making predictions. They also discuss how the creators of this disinformation content intentionally present it in a biased manner, as a quick glance at the information displayed would not be sufficient to draw the conclusions that lead individuals to adopt them. This comparison opens possibilities to reflect on how disinformation narratives with the same ideological content are produced, spread and interpreted in essentially the same way across different social media networks.

Conclusions

Given our goal of analyzing how these narratives circulate in a virtual community, focusing on identifying how mathematics and statistics are used to construct arguments, support scientific denialist points of view or question the validity of information from scientific institutions, we can highlight some of our findings in response to this objective. Broadly speaking, we noticed a clear denialist stance reinforced by individual searches for a so-called truth, with the label “denialist” being consciously embraced by the community members and even considered a source of pride. Regardless of the use of mathematical and statistical language, common patterns in spreading disinformation about the construction of science are evident within this community. Regarding mathematical and statistical knowledge more specifically, we identified difficulties in interpreting graphs, challenges involving grasping large numbers, misconceptions about what constitutes a statistically significant sample, and the use of percentages without a critical awareness of their actual meaning.

Our results show that users employ scientific disinformation discourses to fuel denialism toward information from scientific institutions, using mathematical and statistical knowledge to validate pre-existing and ideological conceptions. This in turn highlights flaws and gaps in the development of mathematical and statistical literacy. As external observers, we cannot determine whether the individuals initiating the spread of disinformation do so knowingly, i.e., with the intent of using seemingly credible language to mislead their audience. However, individuals who come across such discourses on their social networks may think they are true because they lack the necessary tools for critical analyses based on principles of logic, abstraction and mathematical communication.

As we have seen, these three dimensions are interconnected: logic organizes reasoning, abstraction expands understanding and communication ensures that all of this is conveyed clearly. When developed together, they not only enhance individuals' ability to comprehend information but also encourage more ethical and informed participation in public debates. With these tools, individuals can engage more actively and consciously in discussions by understanding information and its implications in alignment with scientific consensus.

In the educational field, our research suggests that teaching strategies should focus on developing these dimensions through specific practices, which we outline below.

By incorporating debates on current topics, including simulations of real-world problems, educators can encourage discussions on controversial issues, helping students identify argumentative flaws, construct logical arguments and critically assess their own opinions. Hands-on activities may involve analyzing data on topics such as epidemics or the effects of climate change, connecting classroom discussions to broader social debates and contextualizing the content. For example, Almeida and Dias (2004) show how mathematical modeling as a teaching strategy enables students to link school syllabi to real-world problems, providing more in-depth learning and critical thinking. Such activities can help students structure reasoning through logic, apply abstraction to think beyond the concrete and articulate thoughts in a way that bridges abstract and concrete concepts.

We also emphasize the importance of critically analyzing distorted information. Examining manipulated graphs and misleading news can help students develop critical thinking by identifying errors while also strengthening logical reasoning through pattern recognition. Monteiro and Marcelino (2022) conducted similar work in science education, using disinformation about a supposed link between microwave use and cancer to develop scientific literacy. By investigating the topic, students analyzed the arguments presented in misleading content and how they distorted information.

Similarly, creating visual and argumentative materials — such as infographics or data-based texts — enhances students' ability to translate technical concepts for a broader audience. These activities highlight the role of effective communication and presentation in shaping public understanding of important issues.

These examples can be supplemented by interdisciplinary projects. Integrating mathematics, language and social sciences helps students critically assess how numbers can be used to support narratives, aligning with Skovsmose's (2000, p. 2) perspective on critical mathematics education. According to Skovsmose, mathematics education should develop not only technical skills but also "the competence to interpret and act in a social and political situation structured by mathematics."

Besides reinforcing logic, abstraction and communication skills, such strategies also contribute to teaching citizenship, empowering individuals to engage actively and responsibly in social and political matters, as critical mathematics education supports democracy (Skovsmose, 2000). Countering the dissemination of disinformation requires more than just fact-checking—it demands a widespread and ongoing effort to develop cognitive, ethical and social competencies.

Thus, we also stress the importance of political literacy in enabling individuals to analyze the political, economic and ideological interests behind the spread of disinformation. Works by McIntyre (2018, 2021), Oreskes and Conway (2010), and Pivaro and Girotto Jr. (2020, 2022, 2023) highlight how scientific disinformation is often deployed as a political strategy to advance projects aligned with maintaining the hegemonic neoliberal system.

Strengthening political literacy alongside mathematical and statistical literacy enhances civic engagement and public pressure for policies capable of providing quality of life and collective well-being. As our research—conducted in a pandemic context—demonstrates, low levels of political, mathematical and statistical literacy led thousands of people to life-threatening risks, as they distrusted scientific consensus on vaccine efficacy and alternative treatments, for example.

Lastly, we believe that it is essential for learning environments to prioritize the integration of logic, abstraction and communication, as these skills are key to educating individuals who are prepared to critically evaluate misleading discourses when navigating information-rich environments.

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References

Almeida, L. M. W. de, & Dias, M. R. (2004). Um estudo sobre o uso da modelagem matemática como estratégia de ensino e aprendizagem. *Bolema, 17*(22), 1-24

Amorim, F. (2019, 15 de dezembro). *Bolsonaro diz que pressão sobre mudança climática é "jogo comercial"*. UOL. https://noticias.uol.com.br/meio-ambiente/ultimas-noticias/redacao/2019/12/15/bolsonaro-diz-que-pressao-sobre-mudanca-climatica-e-jogo-comercial.htm

Angrosino, M. (2009). *Etnografia e observação participante.* Porto Alegre: Artmed.

Antoniassi, M., & Dias, F. A. S. (2022). Letramento estatístico: uma revisão de literatura com artigos do banco de dados ERIC. *JIEEM – Journal of Informatics, Educational and Management Sciences, 25*(3), 304–313. https://doi.org/10.17921/2176-5634.2022v15n3p304-313

Araujo, R. F., & Oliveira, T. M. (2020). Desinformação e mensagens sobre a hidroxicloroquina no Twitter: da pressão política à disputa científica. *AtoZ: Novas práticas em informação e conhecimento, 9*(2), 196–205. https://doi.org/10.5380/atoz.v9i2.75929

Benites, A. (2018, 28 de setembro). *A máquina de 'fake news' nos grupos a favor de Bolsonaro no WhatsApp*. El País. https://brasil.elpais.com/brasil/2018/09/26/politica/1537997311_859341.html

Bianchi, L. E. (2007). *A lógica no desenvolvimento da competência argumentativa* [Tese de doutorado, Universidade Estadual Paulista]. http://hdl.handle.net/11449/102152.

Cardoso, D. (2025, 15 de fevereiro). *Pesquisa revela aumento de discurso de ódio no X após compra por Elon Musk*. Notícias, Tecnologia. E. M. Foco. https://www.em.com.br/emfoco/2025/02/15/pesquisa-revela-aumento-de-discurso-de-odio-no-x-apos-compra-por-elon-musk/

Cazorla, I. M., & Castro, F. C. (2008). O papel da estatística na leitura do mundo: o letramento estatístico. *Publicatio UEPG: Ciências Humanas, Linguística, Letras e Artes, 16*(1), 45–53.

Cesarino, L. (2022). Bolsonarismo sem Bolsonaro? Públicos antiestruturais na nova fronteira cibernética. *Revista do Instituto de Estudos Brasileiros,* (82), 162–188.

D'Ancona, M. (2018). *Pós-verdade: A nova guerra contra os fatos em tempos de fake news* (C. Szlak, Trad.). Barueri: Faro Editorial.

Dias, M. (2019, 11 de setembro). *Nos EUA, Ernesto critica 'climatismo' e diz que debate é 'pretexto para ditadura'*. Folha de S. Paulo. https://www1.folha.uol.com.br/mundo/2019/09/nos-eua-araujo-critica-climatismo-e-diz-que-debate-e-pretexto-para-ditadura.shtml

English Oxford Living Dictionaries. (2016). *Word of the Year 2016 is….* https://languages.oup.com/word-of-the-year/2016/

Fernandes, C. M., Oliveira, L. A. de, Campos, M. M. de, & Coimbra, M. R. (2020). A Pós-verdade em tempos de Covid-19: O negacionismo no discurso de Jair Bolsonaro no Instagram. *Liinc em Revista, 16*(2), e5317. https://doi.org/10.18617/liinc.v16i2.5317

Gal, I. (2002). Adult statistical literacy: Meanings, components, responsibilities. *International Statistical Review, 70*(1), 1-25

Gastaldi, F. C. (2018). Gramsci e o negacionismo climático estadunidense: A construção do discurso hegemônico do antropoceno. *Revista Neiba, Cadernos Argentina Brasil, 7*(1), e39247. https://doi.org/10.12957/neiba.2018.39247

Girotto Jr., G., Vasconcelos, C. A., & Pivaro, G. F. (2022). Hiperparticularización de conceptos, negativismo científico y naturaleza de la ciencia: un análisis de las respuestas a los textos de divulgación científica. *Prometeica - Revista De Filosofía Y Ciencias*, (24), 113–130

Guimarães Jr., M. J. L. (2005). Doing anthropology in cyberspace: Fieldwork boundaries and social environment. In C. Hine (Ed.), *Virtual methods: Issues in social research on the internet* (pp. 141–156). Oxford, New York: Berg.

Hine, C. (2000). *Virtual ethnography*. Sage.

Hine, C. (2005). Introduction. In C. Hine (Ed.), *Virtual methods: Issues in social research on the internet* (pp. 109–112). Oxford, New York: Berg.

Hine, C. (2015). *Ethnography for the internet: Embedded, embodied and everyday*. London, United Kingdom: Bloomsbury.

Höttecke, D., & Allchin, D. (2020). Reconceptualizing nature-of-science education in the age of social media. *Science Education, 104*(4), 641–666. https://doi.org/10.1002/sce.21575

Huff, D. (1993). *How to lie with statistics*. New York: W.W. Norton & Company

Jablonka, E. (2003). Mathematical literacy. In A. J. Bishop, M. A. Clements, C. Keitel, J. Kilpatrick, & F. K. S. Leung (Eds.), *Second international handbook of mathematics education* (pp. 75–102). Kluwer Academic Publishers. https://doi.org/10.1007/978-94-010-0273-8_6

Kapantai, E., Christopoulou, A., Berberidis, C., & Peristeras, V. (2021). A systematic literature review on disinformation: Toward a unified taxonomical framework. *New Media & Society*, *23*(5), 1301–1326. https://doi.org/10.1177/1461444820959296

Massarani, L., Costa, M. C. R., & Brotas, A. (2021). Enquadramentos e desinformação sobre vacina contra COVID-19 no YouTube: Embaralhamentos entre ciência e negacionismo. *Revista Mídia e Cotidiano, 15*(3), 73–100.

McIntyre, L. (2018). *Post-truth.* Cambridge, MA: The MIT Press.

McIntyre, L. (2021). *How to talk to a science denier: Conversations with flat earthers, climate deniers, and others who defy reason.* Cambridge, MA: MIT Press.

Monteiro, M. M., & Marcelino, V. D. S. (2022). Ensinar ciências por investigação em tempos de pandemia: promovendo a alfabetização científica por meio da abordagem de uma fake news sobre o câncer. *Revista Brasileira de Ensino de Ciências e Matemática*, *5*(1), 666-688. https://10.5335/rbecm.v5i1.12926

OECD (2013), *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*, PISA, OECD Publishing, Paris, https://doi.org/10.1787/9789264190511-en.

Oliveira, J. (20 de out. 2021) *Bolsonaro é "líder e porta-voz" das 'fake news' no país, diz relatório final da CPI da Pandemia.* El País. https://brasil.elpais.com/brasil/2021-10-20/bolsonaro-e-lider-e-porta-voz-das-fake-news-no-pais-diz-relatorio-final-da-cpi-da-pandemia.html

Oliveira, T. M. (2019). Autoridade científica em tempos de crise epistêmica: A circulação de teorias da conspiração nas mídias sociais. *Atas do XXVIII Encontro Anual da Compós*, Porto Alegre, RS, 1–23.

Oliveira, T. M. (2020). Como enfrentar a desinformação científica? Desafios sociais, políticos e jurídicos intensificados no contexto da pandemia. *Liinc em Revista*, *16*(2), e5374. https://doi.org/10.18617/liinc.v16i2.5374

Oliveira, T. M., Martins, R. Q. R., & Toth, J. P. (2020) Antivacina, fosfoetanolamina e Mineral Miracle Solution (MMS): mapeamento de fake sciences ligadas à saúde no Facebook. *Reciis, 14(1)*, 90-111. https://doi.org/10.29397/reciis.v14i1.1988

Oreskes, N., & Conway, E. M. (2010). *Merchants of doubt: How a handful of scientists obscured the truth on issues from tobacco smoke to global warming.* New York: Bloomsbury Press.

Parker, C., Scott, S., & Geddes, A. (2019). Snowball sampling. In P. Atkinson, S. Delamont, A. Cernat, J. W. Sakshaug, & R. A. Williams (Eds.), *SAGE Research Methods Foundations.* https://doi.org/10.4135/9781526421036831710

Penteado, C. L. De C., Goya, D. H., Dos Santos, P. D., & Jardim, L. (2022). Populismo, desinformação e COVID-19: Comunicação de Jair Bolsonaro no Twitter. *Media & Jornalismo, 22*(40), 239–260.

Pereira, A. A. G., & Figueirôa, S. F. M. (2024). Epistemologia social e desinformação científica: Perspectivas para a educação em ciências. *Ensaio: Pesquisa em Educação em Ciências (Online), 26,* 1–20.

Pivaro, G. F. (2023) *Sobre a propagação de desinformações científicas nas redes sociais: Uma pesquisa etnográfica no Twitter para reflexões sobre a educação em ciências* [Tese de doutorado, Universidade Estadual de Campinas] https://repositorio.unicamp.br/acervo/detalhe/1344618.

Pivaro, G. F., & Girotto Júnior, G. (2020). O ataque organizado à ciência como forma de manipulação: do aquecimento global ao coronavírus. *Caderno Brasileiro de Ensino de Física, 37,* 1074-1098.

Pivaro, G. F., & Girotto Júnior, G. (2022). Qual ciência é negada nas redes sociais? Reflexões de uma pesquisa etnográfica em uma comunidade virtual negacionista. *Investigação em Ensino de Ciências (Online), 27*(1), 435-458.

Pivaro, G. F., & Girotto Júnior, G. (2023). Características dos Discursos de Desinformação Relacionados aos Conhecimentos Científicos das Redes Bolsonaristas no Twitter. *Revista Brasileira de Pesquisa em Educação em Ciências, 23,* e40800.

Rabin-Havt, A. (2016). *Lies, Incorporated: The world of post-truth politics.* Anchor Books.

Recuero, R. (2014). Contribuições da análise de redes sociais para o estudo das redes sociais na Internet: O caso da hashtag #Tamojuntodilma e #CalaabocaDilma. *Fronteiras – Estudos Midiáticos, 16*(2), 60–77. https://doi.org/10.4013/fem.2014.162.01

Recuero, R., Zago, G., Bastos, M. T., & Araújo, R. (2015). Hashtags functions in the protests across Brazil. *SAGE Open, 5*(2), 1–14. https://doi.org/10.1177/2158244015586000

Recuero, R., Soares, F. B., Vinhas, O., Volcan, T., Zago, G., Stumpf, E. M., ... & Sodré, G. (2020). Desinformação, mídia social e COVID-19 no Brasil: Relatório, resultados e estratégias de combate. *MIDIARS.* https://wp.ufpel.edu.br/midiars/files/2021/05/Desinformac%CC%A7a%CC%83o-covid-midiars-2021-1.pdf

Recuero, R., Soares, F., & Zago, G. (2021). Polarização, hiperpartidarismo e câmaras de eco: Como circula a desinformação sobre COVID-19 no Twitter. *Contracampo, 40*(1), 1–17.

Rigon, E. A., & Stamberg, C. S. (2023). Lógica matemática: Desafios e possibilidades na educação básica. *Revista Educação Matemática, 11*(1), Publicação Contínua.

Sales, S. N., & Pereira, A. A. G. (2024). Construção de discurso dos licenciandos sobre a confiabilidade e credibilidade de afirmações sobre o aquecimento global divulgadas nas mídias sociais. *Caderno Brasileiro de Ensino de Física, 41*(1), 123–151. https://doi.org/10.5007/2175-7941.2024.e95967

Santana, M. S. (2016). Traduzindo pensamento e letramento estatístico em atividades para sala de aula: Construção de um produto educacional. *Bolema, 30*(56), 1165–1187. https://doi.org/10.1590/1980-4415v30n56a17

Seife, C. (2012). *Os números (não) mentem: Como a matemática pode ser usada para enganar você*. Rio de Janeiro: Zahar

Scolari, A. T., Bernardi, G., & Cordenonsi, A. Z. (2007). O desenvolvimento do raciocínio lógico através de objetos de aprendizagem. *Anais do Congresso Internacional de Educação e Tecnologias*, Universidade Federal de Santa Maria

Seibt, T. & Dannenberg, M. (2021) Pandemia, desinformação e discurso autoritário: os sentidos das declarações de Jair Bolsonaro no Twitter a partir de checagens do Aos Fatos. *Liinc em Revista*, *17*(1), e5687. https://revista.ibict.br/liinc/article/view/5687

Silva, D. C. P. (2020) Embates semiótico-discursivos em redes digitais bolsonaristas: populismo, negacionismo e ditadura. *Trabalhos em Linguística Aplicada*, *59*(2), 1171-1195. https://periodicos.sbu.unicamp.br/ojs/index.php/tla/article/view/8658484

Skovsmose, O. (2000). Cenários para investigação (J. C. Barbosa, Trad.). *Bolema*, *13*(14), 1–24

Soares, F, B. (2020) As estratégias de argumentação e as formas de desinformação nas mensagens de Jair Bolsonaro no Twitter durante o segundo turno das eleições presidenciais de 2018. *Mediação*, *22*(30), 8-22.

Soares, F. B., Viegas, P., Sudrack, S., Recuero, R., & Huttner, L. R. (2019). Desinformação e esfera pública no Twitter: Disputas discursivas sobre o assassinato de Marielle Franco. *Fronteiras – Estudos Midiáticos*, *21*(3), 2–14.

Souza, L. de O. (2017). Possibilidades de insubordinação criativa no ensino de Estatística. *Revista de Ensino de Ciências e Matemática*, *8*(4), 253–272.

Souza, L. de O., & Araújo, J. de L. (2022). O fenômeno das fake news: Formação de crenças sob a ótica pragmatista e a Educação Matemática. *Acta Scientiae*, *24*(1), 1–29.

Souza, L. de O., Araújo, J. de L., & Pinto, T. F. (2022). O fenômeno da desinformação e o papel dos números na comunicação: Concepções de professores e futuros professores de Matemática. *Educação Matemática em Revista - RS*, *2*(23).

Spinelli, E. M., & Santos, J. A. (2020). Alfabetização midiática na era da desinformação. *ECCOM*, *11*(2), 147–164.

Spinelli, W. (2011). *A construção do conhecimento entre o abstrair e o contextualizar: O caso do ensino da Matemática* [Tese de doutorado, Universidade de São Paulo]. http://www.teses.usp.br/teses/disponiveis/48/48134/tde-10062011-134105/

Talwar, S., Dhir, A., Haur, P., Zafar, N., & Alrasheedy, M. (2019). Why do people share fake news? Associations between the dark side of social media use and fake news sharing behavior. *Journal of Retailing and Consumer Services*, 51, 72–82.

Uriarte, U. M. (2012). O que é fazer etnografia para os antropólogos. *Ponto Urbe*, (11), 1–13. https://doi.org/10.4000/pontourbe.300

Vilela, M. L., & Selles, S. E. (2020). É possível uma Educação em Ciências crítica em tempos de negacionismo científico? *Caderno Brasileiro de Ensino de Física*, *37*(3), 1722–1747.

Walichinski, D. (2012). *Contextualização no ensino de estatística: Uma proposta para os anos finais do ensino fundamental* [Dissertação de mestrado, Universidade Tecnológica Federal do Paraná]. Repositório Institucional da UTFPR.

Wardle, C., & Derakhshan, H. (2017). *Information disorder: Toward an interdisciplinary framework for research and policymaking*. Strasbourg: Council of Europe.

Wild, C. J., & Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, *67*(3), 223–265. https://doi.org/10.1111/j.1751-5823.1999.tb00442.x

Wu, L., Morstatter, F., Carley, K. M., & Liu, H. (2019). Misinformation in social media: Definition, manipulation, and detection. *ACM SIGKDD Explorations Newsletter, 21*(2), 80–90