OTHER THEMES

Pseudosciences and the Current Challenges Imposed on Science Teaching

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ABSTRACT – Pseudosciences and the Current Challenges Imposed on Science Teaching. The article presents conceptual reflections on pseudosciences, introduces the psychological nature of pseudoscientific beliefs, and exposes some indications of how widespread they are among Brazilians and their harmful effects in the context of the COVID-19 pandemic. Some indications taking advantage of the excess of information and inaccurate critical and scientific thinking of the general population, pseudoscientific beliefs were disseminated through fake news, denialism, and conspiracy theories to the point of shaping narratives and public policies. It then presents clear and concise strategies for improving science teaching to combat pseudoscience.
Keywords: **Negacionism. Fake News. Conspiracy Theory. Cognitive Bias.**

RESUMO – Pseudociências e os Desafios Atuais Impostos ao Ensino de Ciências. O artigo se propõe a apresentar reflexões conceituais sobre as pseudociências, introduzir à natureza psicológica das crenças pseudocientíficas, expor alguns indícios do quanto estão disseminadas entre brasileiros e seus efeitos danosos no contexto da pandemia de COVID-19. Há indícios que, aproveitando-se do excesso de informações e pensamento crítico e científico pouco acurado da população em geral, as crenças pseudocientíficas foram disseminadas através de *fake news*, negacionismo e teorias da conspiração a ponto de moldar narrativas e políticas públicas. Apresenta-se então algumas estratégias claras e concisas sobre como o ensino de ciências pode ser aprimorado com o objetivo de combater as pseudociências.
Palavras-chave: **Negacionismo. Fake News. Teorias da Conspiração. Viés Cognitivo.**

Introduction

Science teaching has undergone profound social, cultural, and political challenges, which were evidenced and aggravated due to the recent COVID-19 pandemic, feeding inadequate views about scientific knowledge and its workings (Catarino; Reis, 2021). In addition to the disease, there is also an infodemic characterized by an overabundance of information that makes it difficult for people to find reliable sources, leaving them at the mercy of false news and lost among the claims of scientists, politicians and other agents who dispute narratives about science (Oliveira, 2020).

An epistemic crisis is then observed, where scientific institutions and universities are viewed with suspicion while denialist and conspiratorial views (such as flat earth or anti-vaccine movements) presented by digital platforms and social networks gain excessive projection (Albuquerque; Quinan, 2019). Part of the erroneous views conceived by people can be called pseudoscience, that is, beliefs that seek to appear equivalent to scientific thinking, but that fail in fundamental premises in the construction of their own logic, become incompatible with the knowledge brought by the sciences already well established (Pilati, 2018).

Considering the current scenario of dissemination of pseudosciences, the present work is a reflective essay about objective approaches aimed at implementing science teaching that confronts pseudoscientific beliefs. To this end, it begins by addressing clear measures with the aim of facilitating its use by science teaching without imposing an end to the debate about what pseudoscience is or is not. This discussion allows us to discuss the psychological reasons that lead people to erroneous beliefs, how pseudosciences take advantage of cognitive failures, and the need to fill in knowledge gaps that many people carry.

The complexity of teaching science, given the reality of Brazilian education, goes far beyond the application of teaching methods. However, this should not be an impediment to teaching-learning proposals already brought by scientific research to be adapted to the sociocultural context of students. In this way, possible paths are presented for an education that aims, in addition to the formation of critical and scientific thinking, to combat pseudoscientific conceptions that cloud society's vision.

A brief definition of pseudoscience

It is fair to say that demarcating the division between science and pseudoscience is a swampy ground because the very definition of scientific knowledge is not definitive; however, a more fruitful strategy would be to identify the evils or characteristic traits of pseudoscience (Silva, 2016). From this thought, the literature review by Hansson (2021) defines pseudosciences: sustain that a person or a group has a special ability to determine what is true and false; they credit unre-

peatable experiments; use biased examples; do not test theories, although they are testable; disregard refuting observations and experiments; organize theories so that they can only be confirmed; and abandon explanations and theories as they see fit.

Philosopher Mario Bunge (2017) complements this by highlighting four elements of distinction between scientific and pseudoscientific thinking: unlike the temporal mutability of science, pseudosciences are characterized by static ideas and concepts that conveniently change only when there is pressure from a group who holds power; they can be learned in a short space of time due to their little elaborated knowledge; pseudosciences are worked on in isolation because they do not overlap with other areas of research, which occurs, for example, between psychology and neuroscience in relation to the study of the mind; Contrary to what happens in science, pseudosciences do not act in a self-doubting, self-correcting and self-perpetuating manner, prioritizing the search for absolute truths.

For the philosopher Martin Mahner (2007), the term pseudoscience is often used incompletely because it only considers knowledge that falsely claims to be science and ignores those that are equivalent or complementary to scientific knowledge even though they do not claim to be science. . The author then suggests that pseudosciences can be divided into three groups: non-scientific approaches with the aspiration to be called science (e.g. scientific creationism or intelligent design, ufology, astrology, psychoanalysis, homeopathy, etc.), approaches that do not present scientific claims , but denote equality or superiority to scientific knowledge (e.g. traditional Chinese medicine, acupuncture, etc.) and those that address supernatural techniques (e.g. esotericism, tarot, faith healing, etc.).

Hanson (2021) also assesses that science denial is a form of manifestation of pseudosciences, as they promote pseudotheories that mimic scientific theories (homeopathy, astrology, theories about ancient astronauts, etc.) and/or openly act against science statements (denial Holocaust, climate change denial, anti-vaccine movements, etc.). Furthermore, pseudosciences often appeal to emotions and end up satisfying needs that science fails to satisfy, such as offering spiritual satisfaction and supposed cures for diseases (Sagan, 2006).

It is not intended to extinguish any future discussion regarding the definitions of pseudoscience here, although it is clear that there are many points of agreement between the cited authors. However, just as important when looking for definitions is understanding the reasons that lead people to believe in pseudoscientific concepts.

The foundations of pseudoscientific beliefs

Many pseudosciences are related to the human mind's susceptibility to misinterpreting the world around it. According to the Dual Process Theory (Kahneman, 2011), humans respond to the environment in two ways. The first, called intuitive reasoning, is characterized by being fast, generating automatic actions without mental effort

(such as walking or cycling), creating a notion of normality (searching for patterns of events in the environment in accordance with personal experience), and attempt to anticipate future events through memory (such as imagining the traffic situation when returning home after a day of work) (Pohl, 2017). However, some situations require more precise analysis, thus demanding analytical reasoning, described as more logical and requiring greater effort and concentration (Moore, 2017).

Analytical and intuitive reasoning are closely related, the latter being particularly important in decision-making, although flawed due to the propensity to infer and invent causes and intentions, minimize doubts, tendency to believe carelessly, maximize emotional effects, etc. (Kahneman, 2011). However, it is important to highlight that intuitive reasoning is instrumental in making judgments in simpler tasks that require quick responses, just as analytical reasoning can make mistakes even if it is more precise (Evans, 2019). But due to the way intuition works, there is a greater chance of errors in decision-making, often without being noticed and with the risk of being accepted as correct over time (Daws; Hampshire, 2017; Kubricht; Holyoak; Lu, 2017; Pohl, 2017; Bronstein et al., 2019).

It is common for a wrong decision to be related to one of several types of cognitive bias, that is, a pattern of judgment distortion that occurs in specific situations of misinterpretation of circumstances, resulting in distorted perceptions, inaccurate judgments, and illogical conclusions (Haselton; Nettle; Andrews, 2005). Mlodinow (2014) exemplifies a case of cognitive bias when volunteers in an experiment were recruited to taste different wines with a price displayed on the label and were unaware that all the bottles had the exact wine. As confirmed by the Functional Magnetic Resonance Imaging (fMRI) device, it was demonstrated that the majority had a greater perception of pleasure in a US$90 bottle compared to those US$10 (Mlodinow, 2014).

For Rogers, Fisk, and Lowrie (2018), the so-called conjunction bias was identified through research as closely related to the belief in the paranormal (e.g., precognition, witchcraft, telekinesis, superstitions). Such a bias creates a perceptual error where the probability of two events occurring simultaneously is seen as more likely than them occurring in isolation, such as considering the act of thinking about a friend (event 1) who unexpectedly calls (event 2) as an extraordinary event that can only be explained by something supernatural such as luck or destiny (Fisk; Lowrie, 2016).

Van Elk (2017) also talks about the correlation between self-retribution bias and belief in the paranormal (including superstitions and religious beliefs), where the individual attributes negative events to external factors such as supernatural causes or bad luck, while positive events are attributed to own merit. Such bias can also induce the false perception that supernatural forces can be understood and even controlled, such as believing in the superstition that knocking on wood can make it impossible for bad events to happen.

A characteristic cognitive property of humans is the tendency to search for patterns in the environment through the connection of events, organization of the components involved, and subsequent interpretation according to individual concepts (Maraldi; Martins, 2017). However, it is not uncommon for many events to have no connection with each other and be random, even if the observer perceives some connection between events, thus leading to false causality bias (Blanco, 2017).

The experiments by Griffiths et al. (2018) observed that most people are prone to false causality bias and that those with the highest propensity commonly have a high level of superstitious beliefs (such as believing in luck). Similar results were detected by Torres, Barberia, and Rodríguez-Ferreiro (2020) when demonstrating that people with a greater tendency to develop illusions of causality are prone to greater acceptance of superstitions and popular pseudosciences (e.g., homeopathy, reiki, graphology, etc.).

Returning to the theme of the paranormal, Chauvin and Mullet (2018) carried out a study demonstrating that believers in the paranormal are commonly characterized by an exacerbated trust in intuition, excessive appreciation of personal experiences, and creative imagination (e.g., more fanciful and artistic people show an inclination towards beliefs such as ghosts, astrology, and divination). However, an important aspect of followers of the supernatural is related to the feeling of anxiety/fear since believing in reincarnation, for example, can bring a sense of security in the face of the uncertainties of death.

For many people, the feeling of lack of control and uncertainty generates an aversive cognitive response, leading to feelings of stress and anxiety, exemplified by times when chronic diseases such as cancer or economic insecurity are involved (Kay et al., 2008; Wright; Afari; Zautra, 2009). In these situations, logical responses may be ignored due to weakened judgments arising from non-rational cognitive processes (Lieder et al., 2017). Legare and Souza (2014) identified that, in events where there is a desire to establish a feeling of control, sympathies (ritualistic procedures that seek to resolve everyday problems) are often seen as more effective, as Rodrigues (2017) states that in places that cause feelings of anxiety (socially unequal and violent), the acceptance of astrology is strengthened based on the supposed predictability generated by this belief.

The feeling of fear and uncertainty was also observed by Bavel et al. (2020) during the COVID-19 pandemic, manifesting itself through social behaviors such as optimism bias, where people avoid negative emotions in such a way that it can lead to underestimating the probability of contracting the disease; little factual basis in decision making; increase in prejudiced behavior directed at Asian ethnic groups; incitement to the feeling of panic caused by the excessive stockpiling of supplies; increased political polarization; belief in conspiracy theories that lead to denial by health authorities and the use of ineffective medicines (Bavel et al., 2020).

Although necessary, the quarantines carried out during the pandemic reinforced the perception of lack of control due to physical-affective isolation and the infodemic. This factor was observed by Escolá-Gascón et al. (2020), who also detected, after a period of quarantine, a significant increase in psychotic symptoms (mainly hallucinations), paranoid experiences, and depressive symptoms in people without a history of previous psychiatric illnesses, thus being a favorable scenario for pseudosciences that bring cognitive comfort and fuel anomalous perceptions (such as hallucinations that invoke supposedly supernatural experiences).

It is then observed that unwanted sensations can be reduced through the feeling of control and predictability achieved through the illusory perception of discovering potential causes (Blanco, 2017). As stated by Daws and Hampshire (2017), this factor has a strong influence on religious dogmas, as it was identified that in tasks where logical answer conflicts with intuitive reasoning (such as pre-conceived ideas based on religion), people with greater Religious dogmatism (raised or not by religious families) manifest cognitive biases more frequently when compared to non-religious individuals (even those raised by religious families).

When it comes to religious beliefs, it is common for cognitive conflicts to arise during the science teaching process, which can harm learning, considering that many students carry an interpretation of the world based on religious authorities and biblical quotations (Dutra; Antunes, 2019). Wagner-Egger et al. (2018) corroborate this by stating that religious beliefs reinforce teleological thinking (attribution of purpose and a final cause to worldly events) from childhood and can last until adulthood. According to the authors, teleological thinking can make it difficult to adopt scientific concepts and encourage the acceptance of conspiracy theories since many fall into the teleological bias of explaining socio-historical events from the perspective of hypothetical secret conspiracies.

Conspiracy theories provide causal explanations for complex social events with the aim of offering alternative conceptions to official facts, suggesting that the truth is being hidden by people and institutions, such as believing that AIDS was created by the US government for population control (Rezende et al ., 2019). For Douglas, Sutton, and Cichocka (2017), three reasons lead an individual to believe in conspiracy theories: epistemic reasons (seeking causal explanations that reduce the feeling of uncertainty), existential reasons (bringing a sense of security through the revelation of supposed plans and hidden threats) and social reasons (feeling of belonging when inserted into groups that think in an ideologically similar way).

Contrary to common sense, intelligent people are still susceptible to conspiracy theories involving social and political issues, even if they are more attached to scientific explanations. This fact was reported by Jastrzębski and Chuderski (2017), who identified that intelligent individuals have a greater ability to find quality arguments that

support their pre-existing beliefs and are not necessarily willing to consider contrary evidence and alternative perspectives. This factor was identified in a study conducted by Kahan et al. (2012), where it was observed that personal beliefs aligning with the individual's social group have more weight in the perception of global climate change than the degree of scientific literacy.

As Marques (2009) reports, individuals feel welcomed in groups when they develop an illusion of invulnerability, the belief that there is an inherent morality in the group, and the psychological satisfaction of socially pursuing common goals. Characteristics like these enable the development of beliefs within pseudoscience groups (e.g., ufology, religious extremists, flat earthers). As the group influences a newly initiated person, their conceptions become more ingrained and acquire additional layers of complexity (Martin, 2018). According to Martin (2018), small increases in complexity tend to be cognitively more acceptable than large changes, which explains, for example, how the simple belief that lights in the sky are extraterrestrial ships can gradually transform into the idea that there are aliens infiltrating governments.

Even though some pseudosciences have a harmless appearance, there is evidence that people with greater pseudoscientific beliefs, in general, tend to endorse health practices without scientific support (e.g., homeopathy, acupuncture, ozone therapy, etc.), leaving room for rejecting effective treatments and the use of medicines without proof (Taschner et al., 2021). At the same time, the perception that practices such as homeopathy and acupuncture are scientifically based (due to the recommendation of doctors or presence in pharmacies) is positively associated with interest and trust in science, indicating that acceptance is not due to mere superstition, but rather due to erroneous conception about the scientific validity of these practices (Lobera; Rogério-García, 2020).

It is noted that many pseudosciences are related to cognitive biases that cause errors in interpretation and the aversion to anxiety that drives the search for beliefs that bring a feeling of certainty and veracity. Religious beliefs, local culture, and belonging to specific social groups frequently trigger this sense of comfort, creating a space where misconceptions aligned with these beliefs can be readily embraced. Many people may resist science as a promoter of questioning, as comforting pre-conceived ideas are challenged, which is reinforced by a lack of understanding of how science works and the absence of the habit of thinking critically.

Pseudoscience, *fake news* and post-truth

In recent years, the term fake news has gained much popularity. It is defined as false news created to misinform, manipulate public opinion, and exploit the rapid spread of information. Typically, its origin is challenging to trace, capitalizing on the general population's lack of critical discernment (Gelfert, 2018; Schiele, 2020). With the ex-

acerbated increase in the dissemination of false information, the term "Post-Truth Era" was coined to describe today's society as "circumstances in which objective facts are less influential in shaping public opinion than emotional appeals and personal beliefs" (Knight; Tsoukas, 2019).

In this Post-Truth Era, authorities, notably political ones, appeal to their version of facts through narratives that disregard scientific evidence, while many people seek to believe only in figures they trust and in their own perceptions of reality (Fujimura; Homes, 2019). This is evident in how pseudosciences can proliferate, exploiting the public's disconnection from scientific principles due to shortcomings in the science education system (Guzzo; Guzzo, 2015).

In this sense, the context of pseudosciences in Brazil can be addressed through research into the general public's understanding of science. The Wellcome Global Monitor 2018 (Gallup, 2019) demonstrated some aspects of Brazilians' views on science: 13% entirely distrust Brazilian scientists while 24% have little trust; 5% trust completely and 15% partially trust traditional healers; 23% have little faith in science; 30% admit they know nothing about science; 38% do not believe in the benefits brought by the work of scientists for themselves; 75% said that when science and religion disagree, they prefer to choose religion.

The Instituto Questão de Ciência (ICQ), in partnership with the Instituto Datafolha (Orsi, 2019), demonstrated that of the 2,091 Brazilians interviewed, 83% partially or completely agree that alternative medicine is a good option for treating diseases, 66% accept that spiritual energy has healing power, just as 38% believe that governments hide information about aliens. Complementing this information, a survey carried out by the Center for Management and Strategic Studies of the Ministry of Science, Technology, Innovations and Communications (CGEE, 2019) identified that 16.1% completely agree and 24.4% partially agree with the influence of the horoscope in personality; 13.7% completely agree and 28.5% partially agree that scientists exaggerate the effects of climate change; 31.5% completely disagree with the Theory of Evolution of Species; 35% consider that learning about science is not vital for everyday life.

The data indicate that misconceptions about science are widespread among Brazilians. Without knowledge of the foundations of scientific knowledge and a sense of distrust in science and scientists, fertile ground is created for personal beliefs and opinions to be based on pseudoscience (Callaghan, 2019). This aspect is of great importance because of the risks that pseudoscientific beliefs and conspiracy theories are related to decisions that influence society, especially when today's society presents a growing social polarization based on unjustified beliefs and radical discourses (Fasce; Adrián-Ventura; Avendaño, 2020).

Pseudoscience and Pandemic

In the chaotic environment of the COVID-19 pandemic, there is a disastrous irony that the fake news phenomenon itself has been propagated like a disease by the media in a field where many people are not properly vaccinated against misconceptions. It didn't take long for this phenomenon to influence pseudoscientific and conspiracist approaches: ideas about the virus having been artificially created in a laboratory in China, use of medicines without scientific proof, exaggerated accumulation of goods, and involvement in risky behaviors that increase the chances of spread of the virus (Pennycoock et al., 2020).

In an analysis carried out by Galhard et al. (2020) on fake news received between March 17th and April 10th on social networks, it was identified that 65% of them taught homemade methods to prevent the spread of COVID-19, 20% showed homemade methods to cure the disease and 4.3% dealt with the use of the new coronavirus as a political strategy. The authors also state that 62% of Brazilians do not know how to recognize whether a message is true or false; in addition to that, around 110 million Brazilians believed fake news about Covid-19; that is, seven out of 10 were willing to believe in at least one disinformative content about the pandemic.

Brazil is particularly notorious due to the anti-scientific and denialist stance of the President of the Republic, who used official channels to invoke false statements about social isolation, defended hydroxychloroquine as an effective medicine against COVID-19, and even fired his health minister after he countered the denialist stances (Ricard; Medeiros, 2020). The effects of the Brazilian federal government's denialism were addressed by Ajzenman, Cavalcanti, and Mata (2020) when they identified that after the President publicly promoted denialist messages, citizens in pro-government locations reduced practicing social distancing measures compared to those places where their support is weaker. In contrast, such differences were statistically negligible before the President's speeches.

The need for vaccination did not prevent then-president Jair Bolsonaro from repeatedly and publicly questioning the effectiveness of vaccines against COVID-19, stating that he would refuse to be vaccinated when offered (Daniels, 2021). At the same time, Gramacho and Turgeon (2021) identified that, even though Brazilians express a strong intention to be vaccinated, the reference to a vaccine from China or Russia reduces the likelihood of vaccination, particularly among those who are openly supportive of President Jair Bolsonaro and hold critical views toward China and vaccination in general. This factor is corroborated by Moore et al. (2021), who state that vaccine refusal is mainly related to the perception of efficacy, fear of adverse reactions, and country of origin.

Brazil has become a clear example of how pseudosciences can be harmful, opening up the possibility of questioning how scientific

knowledge is approached in today's society and even within classrooms and how it can be used as a vaccine against erroneous conceptions. In this sense, Lopes (2021) states that the advent of COVID-19 exposed the lack of knowledge as one of the evils of social inequality and that it "urges us to educate Brazilian children in the principles of science, such as ethics, critical thinking and search of reliable information" (Lopes, 2021).

The classroom as a path to healing

Presenting possible solutions to problems involving pseudosciences is directly related to knowledge of what science is and how it works. Far from addressing all the nuances of the social and political difficulties of education in Brazil, this work will focus on more practical and objective attitudes that any science teacher can use.

It is important to clarify that teaching about science does not necessarily aim to train experts or even scientists in conducting scientific investigations. It can be said that it is more practical in making students understand the logical foundation of an investigation and critically analyze the statements made from the available data (Lederman; Lederman; Antink, 2013). In this way, students are expected to develop new knowledge and skills through teaching strategies that allow analogy or the construction of scientific concepts (Scarpa; Campos, 2018).

When discussing how to approach science teaching, knowing scientific precepts alone increases the chance of accepting scientific consensus (climate change, vaccine safety, etc.) (Weisberg et al., 2020). However, this knowledge is enhanced when approached in conjunction with the habit of asking, "How do we know this?" or "How can we have confidence in this scientific claim?" (Allchin, 2017). Fasce and Picó (2019) demonstrated an effective reduction in pseudoscientific beliefs when theoretical knowledge about scientific foundations, trust in science, and contextualized critical thinking are aligned. Therefore, adequate science teaching must be clearly connected to achieving students' ability to make well-informed decisions about personal and social issues (Lederman; Lederman, 2019).

Many students may have difficulty learning science because they carry certain prejudices about science, such as non-scientific beliefs from religious teaching, conceptual misunderstandings, use of homonymous words that have different meanings in everyday use and science, and retained errors learned in childhood (Suprapto, 2020). Many of these misconceptions have emotional investment, a perception that they have no flaws and cultural reinforcement to be maintained; that is, any educational intervention must evaluate the feelings of uncertainty and aversion that will arise from the cognitive conflict of having previous concepts questioned (Vaughn; Brown; Johnson, 2020). To this end, the authors recommend that students participate in scientific investigations, promoting a sense of usefulness and reading texts that promote refutation arguments.

Because social networks are influential in the transmission of information, it is important to develop scientific media literacy, allowing a well-informed citizen to be able to interpret the scientific information brought by the media and to have a notion of principles about the role of the media in the mediation of scientific knowledge, the importance of experts' point of view, the possibility of news being created to overshadow genuine science, etc. (Höttecke; Allchin, 2020). In this sense, Ku et al. (2019) detected a positive relationship between the ability to think critically and the understanding of how the media works (how news is produced, how journalists can represent reality in different ways, etc.), the habit of checking sources and the notion of the existence of news filtering algorithms.

Finally, argumentation is important in promoting practices such as evaluating alternatives, adequately weighing evidence, and evaluating the potential viability of scientific claims, even though many teachers do not use this approach (Kilinc; Demiral; Kartal, 2017). The construction of arguments based on evidence is enhanced by explicit teaching about what science is and how it works, providing students with the knowledge to solve various socio-scientifically contextualized problems (Khishfe, 2020; Archila; Molina; Mejía, 2020).

Part of learning about critical thinking is understanding that thinking can be biased and fall into cognitive biases but that these can be reduced or eliminated through effort. Complex tasks such as identifying a bias can become an intuitive yet logical activity, considering that logical-intuitive knowledge emerges from a learning process in which key principles have been practiced until automaticity (Neys; Pennycock, 2019). For this to happen, it must be considered that there are positive effects in explicitly addressing reasoning biases in conjunction with training divided into temporally spaced sessions aimed at repeating tasks in different contexts (Janssen et al., 2019).

Final considerations

A discussion was presented about the reasons why people believe in pseudosciences and how they can be harmful when they influence public policies. In terms of Brazil, it is clear that science teaching is deficient and possibly many of the problems encountered require educational policies at national level. However, this article suggests that some simple changes in the teaching-learning process can be applied concomitantly to current curricula. To this end, the change must begin in the training of teachers so that they have an understanding of what pseudosciences are and have educational tools to combat them, both for themselves and their students.

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