



Possibilities of the COVID-19 pandemic context for statistics education: some reflections

Possibilidades do contexto pandêmico COVID-19 para a educação estatística: algumas reflexões

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Abstract

The COVID-19 pandemic is a worldwide epidemiological event in which is demonstrated the power of information, science, mathematics, and statistics to understand policies and impacts on citizen's behavior and public health. People's access to statistical information related to pandemic demanded the mobilization of technical knowledge and their experiences and contextual knowledge. Also, to critically analyze the dissemination of inaccurate or wrong data and the proliferation of misinformation, the general population needs to develop statistical literacy, which will enable them to identify and avoid being influenced by misleading statistical data. The health crisis resulting from the

pandemic is adding to other urgent problems that afflict humanity. In this challenging context, it seems important to rethink the role of mathematics education and statistical education. This paper aims to reflect on statistics education based on the guidelines of the curriculum and teachers' engagement in implementing projects that involve cross-cutting contemporary themes, can make people more supportive and aware of their role in the post-pandemic world.

Keywords: Statistics Education; Statistical Literacy; COVID-19 pandemic; School Education; Contemporary themes.

Resumo

A pandemia COVID-19 é um evento epidemiológico mundial em que é demonstrado o poder da informação, ciência, matemática e estatística para compreender políticas e impactos sobre o comportamento dos cidadãos e a saúde pública. O acesso das pessoas à informação estatística relacionada com a pandemia exigiu a mobilização de conhecimentos técnicos e das suas experiências e conhecimentos contextuais. Além disso, para analisar criticamente a disseminação de dados imprecisos ou errados e a proliferação de desinformação, a população em geral necessita de desenvolver o letramento estatístico, o que lhe permitirá identificar e evitar ser influenciado por dados estatísticos enganosos. A crise sanitária resultante da pandemia acrescenta-se a outros problemas urgentes que afligem a humanidade. Neste contexto desafiante, parece importante repensar o papel da educação matemática e da educação estatística. Este artigo visa refletir sobre como a educação estatística baseada nas orientações do currículo e no envolvimento dos professores na implementação de projetos sobre temas contemporâneos transversais, pode tornar as pessoas mais solidárias e conscientes do seu papel no mundo pós-pandêmico.

Palavras-Chave: Educação estatística; Letramento estatístico; Pandemia da COVID-19; Educação escolar; Temas contemporâneos.

INTRODUCTION

This paper aims to reflect on statistics education based on the guidelines of the curriculum and teachers' engagement in implementing projects that involve cross-cutting contemporary themes, can make people more supportive and aware of their role in the post-pandemic world. Taking advantage of a real context, such an approach can make them aware of how necessary it is to develop skills and knowledge in these disciplinary areas to appraise the information about this new reality, mainly because much of it is associated with mathematical or statistical terms (Aguilar; Castaneda, 2021). The reflections are related to a process that is still ongoing, and that has stimulated educators and researchers from different areas to understand it in its multiple facets. Our proposal is to problematize how the interpretation of statistical data can be a way of interpreting realities. In this way, this article presents some lines of argumentation and interpretation based on a literature review on critical mathematics education and statistical literacy, empirical data provided by the World Health Organization (WHO, 2020) and the Brazilian Ministry of Health (Brasil, 2021), as well as the experiences and expertise of the authors, who come from different disciplinary fields. Given the complexity of this

pandemic, we believe that only an interdisciplinary approach can enhance a broader understanding of the issue, as it is also a social phenomenon, which affects different aspects of people's lives. Hence, we believe that mathematics education and statistical education can help people interpret and analyze this phenomenon by decoding relevant statistical information conveyed in different media and articulating it with other know-hows and knowledge arising from sociocultural aspects that produce a critical and transforming interpretation of realities.

This pandemic has gained public notoriety due to its global and flagrant gravity. This phenomenon also began to be translated by various media through the dissemination of different statistical representations (e.g., graphs, tables, infographics). This use of statistical data seems to have aimed at attributing the phenomenon the legitimate weight of its magnitude, gravity, and development (e.g., Tufte, 2001). However, we want to discuss a perspective that considers the critical role played by the person who interprets the statistical data, because we consider that individuals, when faced with this different information, resort to their prior knowledge, emotions, and worldview to produce interpretations beyond statistical and/or educational knowledge. Therefore, the relevance of considering these socio-symbolic aspects so that they do not become an epistemological barrier that blocks the individual's possibilities of building new knowledge about the phenomena that affect them.

On the formal aspects, we consider that different epidemiological, statistical, and mathematical concepts began to be part of the news and peoples' daily conversations, such as contagion curve, exponential growth, logarithmic scale, lethality rate, mortality incidence, and moving average of the number of cases or deaths. These technical terms are used as part of arguments that support the projections of COVID-19 pandemic scenarios. At the same time, other concepts related to pandemic control strategies to flatten the curve, were added to the daily vocabulary, such as social distance, home isolation, quarantine, community quarantine, lockdown, herd immunity and vaccination coverage. The access and use of those terms permeated conversations about the repercussion of pandemic control measures in the personal, social, economic, and political spheres and were of huge impact on people's daily lives, affecting emotions and decision-making.

As citizens, we are experiencing the pandemic and being subjected to the measures adopted by health authorities, which are based on statistical information. Different countries are handling the crisis in different ways. In Brazil, the central government ignored scientific arguments and, from the beginning, was strongly against social isolation measures due to its economic consequences. They took a long time to implement the vaccination program,

questioned the effectiveness of the vaccines, and implemented a so-called “early treatment,” which consisted in the prescription of drugs of proven ineffectiveness. Despite state and local governments policies, citizens were dependent on their own decision on whether to adhere to the regulations on social distancing and social isolation (WHO, 2020). Citizens’ decisions and personal behavior became crucial to prevent the virus from spreading or expanding and the danger to affect families and community well-being.

To understand the importance of sanitary measures that could contribute to flattening the curve, people had to have statistical literacy, which is not restricted to using statistical and mathematical knowledge but involves concepts associated with other areas, besides ethical posture and personal experience (Gal, 2002; Monteiro; Ainley, 2007; Cazorla; Utsumi, 2010; Queiroz; Monteiro; Carvalho; François, 2017). Therefore, the person would also need to know important contextual aspects, such as considering the health system capacity to take care of people, preventative actions, and the consequences of disease development. However, these literacy aspects were added to other serious economic and social conditions, given the situation of vulnerability of thousands of people who work for their daily livelihood.

Considering this dramatic context of a sanitary and humanitarian crisis, we ask the following questions: what is the role of mathematical education and statistical education in handling a health crisis of COVID-19? How can we elaborate an agenda to discuss the mathematics and statistics that is behind the information conveyed by the media? The research topic has many opportunities to tackle the problems raised. We will emphasize some specific aspects in our discussion. We reflect on whether statistical information conveyed in different media can explain the COVID-19 pandemic or whether this information can be misused, or withheld, to produce misinformation. Our discussions also aim to reflect on how to teach teachers and students to recognize and criticize statistical data in this pandemic context, considering that another knowledge is needed to understand the pandemic. To exemplify our reflections, we present the statistics about the COVID-19 pandemic and how exponential growth and “flattening the curve” can be approached pedagogically. This demonstrates the vital role of statistical education in mastering the knowledge needed to understand this concept, which carries elements from statistics and epidemiology, and mobilizes other know-hows and emotions. Understanding this aspect, for example, can contribute to people’s and communities’ decisions to collaborate with the adopted measures; thus, the “flattening of the curve” becomes a challenge for everyone as citizens and not just a “statistical concept.”

In our reflections, we consider aspects from authors who developed specific theoretical perspectives about critical education and statistical literacy, who shared similar concerns about the importance of the social dimension of teaching mathematics and statistics. In the following section, we present such theoretical aspects to support our discussion. In the third section, we present the context of COVID-19 pandemic worldwide, with a specific focus on the Brazilian situation, and we reflect on the statistical data presented about it. The fourth section discusses pedagogical examples related to statistical modelling of data, which demonstrates how statistics education might support a better understanding of this pandemic. The fifth section brings a proposal of interpretation for the pandemic, and in the sixth section, we present our final considerations.

THEORETICAL DISCUSSION

Freire (1972) develops an original concept of *critical consciousness* (from the Brazilian Portuguese *consciência crítica*) which is an aspect that each individual should develop to perceive social, political, and economic contradictions, and act in a conscious and creative manner against the oppressive elements of reality. Freire (1993) argues that traditional teaching can be viewed as *banking education*, because it is similar to a banking system in which the students are depositories, and the teacher is the depositor. Freire (1972) suggests that the problem-solving situations proposed for *banking education* display a constructed “real world” that is a “background” for the problem. This kind of question contributes to the construction of a “false perception of reality.” Therefore, Freire alternatively proposes *problem-posing education*, in which teachers and students develop their power to perceive critically the way they exist in the world with which, and in which they find themselves; they come to see the world not as a static reality, but as a reality in process, in transformation. Freire also suggests that *out-of-school resources* (e.g., articles, interviews, and graphs from newspaper and magazines) can generate more authentic pedagogical *problem-posing* situations because they are genuine resources from the sociocultural context in which students participate.

Freire (1992) emphasizes that education must be based on authentic and conscious dialogue because this kind of communication is also capable of generating critical thinking. Freire claims that the teaching and learning of mathematics that does not consider the social and political aspects involved might be a useful way to disguise the important role of mathematics as social knowledge.

Studies in *critical mathematics education* (e.g., Skovsmose, 1994; Frankenstein, 1997) are close to Freire's perspective. Frankenstein (1998) suggests that mathematics should be taught as a tool to interpret and challenge inequities in society. Therefore, an important aim of *critical mathematics education* is to enable teachers and students *to read the world*. For example, to accomplish this goal through mathematics teaching, it is necessary to learn how mathematics skills and concepts can be used to understand why and how mathematical and statistical concepts and representations are kinds of descriptions of the world. Frankenstein (1983) argues that knowledge of basic mathematics and basic statistics is an important part of gaining real popular democratic control over the economic, political, and social structures. She emphasizes that liberating the social aspect requires an understanding of technical knowledge that is often used to obscure economic and social realities. Therefore, it is necessary to pay attention to statistics teaching, which is frequently left to "experts" because it is seen as difficult and worthless for most people.

Skovsmose (2008) assumes that mathematics must be taught so that students can appropriate knowledge that helps them make decisions for their well-being and of their community, contributing to construct a more fair society. Mathematics education should have a human dimension that promotes social justice practices, in which solidarity and empathy should be privileged in pandemic times.

According to Gutstein (2003), an essential principle of a social justice pedagogy is to consider students a part of the solution to injustice. School education should enable students to understand more deeply the conditions of their lives and the sociopolitical dynamics of their world, helping them develop active social and cultural identities. Based on Freire's perspective, this educational approach suggests that teachers should pose questions to students to help them address and understand issues in which they are involved, and then begin a process of conscientization (Freire, 1992). Gutstein (2003) conducted a two-year study as a teacher at a public high school with Latino students, working on significant real-life problems that dealt with social injustice. The results suggested that the approach developed students' sociopolitical awareness and positive cultural and social identities. The study also identified that little was done in schools to use mathematics to achieve equality and social justice. However, the researcher warns that, by itself, that developed awareness was not enough to promote social justice at school.

A successful understanding of statistics about society is supported by elements associated with statistical thinking, critical thinking, and contextual knowledge (Kuntze, 2016). For example, Zapata-Cardona (2018) presents and discusses a proposal for statistics

teaching, inspired by the socio-critical paradigm of the critical mathematical education. The proposal is structured based on *statistical investigations* that aim to promote the development of statistical knowledge through the resolution of problems in critical contexts of society that can support critical citizenship. It presents three examples of statistical investigations developed in the school system: cyberdependence, gender equity, and obesity. According to the author, the advantage of working with *statistical investigations* is that it can be approached at any level of education, from a simple format to a complex one where one can work on hypothesis testing, for example, at the university level.

Most statistical information can be manipulated and misrepresented by its owners or those who pay for it (Huff, 1991). Studies in statistics education have already found that statistical data presented by media graphs are frequently used as a journalistic argument from media such as television, newspapers, and magazines (Cazorla; Castro, 2008). Media graphs are also used with errors or alterations that tries to emphasize some results or disguise others (Monteiro; Ainley, 2007). An approach to statistical data linked to critical analysis of reality can contribute to the full exercise of citizenship (Carvalho; Solomon, 2012).

Statistics educators emphasize the need to develop statistical thinking, i.e., understanding how data is generated, analyzed, and can model natural and social phenomena (Wild; Pfannkuch, 1999). However, statistical thinking is only one aspect of statistical literacy, which is comprised of knowledge and dispositional components, according to Gal's model (2002). From his perspective, statistical literacy is an ability to access, understand, interpret, critically evaluate, and express opinions on statistical messages and arguments related to data or issues involving uncertainty and risk.

In light of a broader perspective of statistical literacy, Gal (2002) argues that the knowledge of the context is an important dimension for teaching statistics. People need to develop the ability to ask questions that are important to them (Ainley; Gould; Pratt, 2015), make explicit the validity and quality of statistical information, and unveil the people's worldviews to sustain their decisions critically and consciously.

Gal (2019) argues that for a full exercise of citizenship, people must understand the meanings of data in their context, because what matters is not the data itself, but the answers and insights we seek while interpreting them. He suggests that two conditions describe a meaningful and important context: it should be authentic, and it should invoke a genuine *need to know*, and be of interest to a stakeholder. This perspective argues that the knowledge of context does not consist of a secondary component in the interpretation of data, but the source of statistical literacy processes.

Authors discuss that citizens must have access and be able to analyze and understand official data sets, which are called civic mathematics (Vatter, 1996) and civic statistics (Nicholson; Gal; Ridgway, 2018). Engel (2019) explains that civic statistics is related to various areas of interest for society. For example, demographic changes, crime, unemployment, wage equity, migration, health, racism, among others, are considered civic statistics. These data that are considered real are usually open, official, multivariate, and dynamic, and have different levels of amplitude (local, regional, or worldwide). Although public statistics are necessary for participating in democratic societies, they are usually neglected in regular statistics teaching.

Nowadays, corporations generate big data from citizens who inadvertently or naively agree to convey their personal information. People are unaware of commercial practices and probably may not understand the impact their data trails may have on their life (François; Monteiro; Allo, 2020). Although in many countries there are regulations to avoid misuse of big data, it can be a source for statistical and computational tools to construct profiles related to people's attitudes, desires, and frustrations. This data can induce the public to make decisions according to the interests of the corporations, as predicted by Harari (2018).

The recognition of the importance of promoting statistical thinking and literacy has led several countries to include statistical topics in school mathematics curricula (Batanero; Borovcnik, 2016). In Brazil, the introduction of statistics in the first years of elementary education was prescribed by the National Curriculum Parameters – PCN (BRASIL, 1997, 1998, 2002). The National Common Curricular Base - BNCC (Brasil, 2018) is the current Brazilian curricular guidelines that defined statistics learning expectations and extended the perspective of statistics beyond data handling. This newer curriculum expects students to develop general competencies to approach statistical data such as:

Argue based on reliable facts, data, and information, to formulate, negotiate and defend common ideas, points of view and decisions that respect and promote human rights, socio-environmental awareness, and responsible consumption at local, regional and global levels, with an ethical positioning in relation to the care of oneself, the others and the planet (BRASIL, 2018, p. 9).

The BNCC guidelines want to ensure that students will mobilize knowledge (concepts and procedures), skills (practical, cognitive, and socio-emotional), attitudes, and values to solve complex demands of daily life, fully exercise their citizenship and have access to the world of work. Besides these curricular demands, we argue that statistics teaching at school should expand the possibilities of critical mathematical education, because understanding a

phenomenon from statistical data implies knowing how the phenomenon functions. Therefore, it is necessary to dialogue with different knowledge areas, which demands interdisciplinary and cross-cutting teaching approaches. In the next section, we will elaborate on the technical information about the statistics to represent the COVID-19 reality, with a specific focus on the Brazilian context (most co-authors were in Brazil during the writing of this paper).

THE CONTEXT OF COVID-19 PANDEMIC AND RELATED STATISTICS DATA

The World Health Organization (WHO) defines a pandemic as the worldwide spread of a new disease. The disease associated with COVID-19 is “silent” because 80% of those infected do not present symptoms (asymptomatic). Because of that, the illness spread quickly, and older people or people with chronic diseases, therefore immunosuppressed, who are more susceptible to be infected, developed more severe forms of the disease, leading to saturation of the health systems. Due to the high international mobility of people, the disease spread rapidly worldwide through community transmission since the link between the cases was difficult to be traced. The WHO announcement, classifying COVID-19 as a pandemic, occurred on March 11, 2020, when the disease had already spread outside China, where the outbreak began, causing 119.000 infections in 114 nations and 4.291 deaths (WHO, 2020). Once the announcement was made, it started to demand from governments adequate containment and treatment measures.

The worldwide pandemic monitoring is carried out by WHO through an international reporting system, in which each country reports the epidemiological data of those infected. In statistical terms, the number of infected people (with a positive test for COVID-19) per day and how many of them died. From this information, two key statistical variables are generated: *accumulated number of confirmed cases* and *accumulated number of deaths*. Information is also collected on gender, ethnicity, age, and comorbidities (pre-existing diseases), among others, which allow us to trace the profile of those infected and understand this phenomenon.

The evolution of the pandemic is monitored daily by media that report it for the world, the countries, states, and municipalities, using panels with tables, graphs, and infographics. In addition to the news, reports present the different strategies adopted by the governments of different countries to contain the pandemic. The daily information about COVID-19 can be found on official websites in Brazil, such as state or municipal health departments and the Ministry of Health. However, due to the opposing attitudes of the federal government of Brazil at that time, and the lack of clarity and transparency of the data, the media companies

carried out a consortium to consolidate data directly from the state and municipal health secretariats throughout the national territory, a social effort unheard of in the face of the inaction and denial of the pandemic by federal authorities.

From websites, it is also possible to access statistical data based on studies conducted by public universities and research institutions, such as Fiocruz (Oswaldo Cruz Foundation) and *Observatório COVID-19 BR*. In the case of information about the pandemic in the world, people can turn to official sources such as WHO, Worldometers (2021) or from international university websites such as Johns Hopkins University.

Besides monitoring COVID-19 evolution, citizens can also access statistical data that result from actions adopted by countries to prevent or mitigate the disease and its impacts on the local and the world economies. In this sense, we follow the measures taken by other countries, which obviously reflect political, social, and cultural aspects of each context. For example, in countries where the pandemic process began earlier and which had already experienced H1N1, such as China and South Korea, they took very severe measures and managed to control the pandemic. European countries, on the other hand, with an advantage of at least a month in relation to China, did not give necessary attention, became the pandemic epicenter, eventually taking harsh measures of social isolation.

The case of Brazil is very emblematic in terms of the evolution of the pandemic. In the beginning, Brazil had almost two months of advantage in relation to other countries, and a wide spectrum of procedures were adopted to combat the pandemic, which allowed it to outline social isolation and social distancing. However, this policy was undermined by the very central government, which, against all WHO guidelines, demanded changes in the calculation of accumulated data about confirmed cases and fatalities. These changes in statistics had consequences for the reliability of interpretation of results (Imperial College London, 2020a). Such vast territory is currently placed at a pandemic epicenter, with devastating consequences for the population of approximately 210 million inhabitants (IBGE, 2020), with high levels of social exclusion. The pandemic spread to countryside towns where there is not enough hospital infrastructure, such as ICUs and respirators. In early 2021, the hospital and funeral collapse hit cities in the north of the country, especially Manaus, capital of the state of Amazonas, when hundreds of people died waiting for an ICU bed and oxygen. Despite the warning of scientists and epidemiologists, the central government was unable to prevent this tragedy (G1-Globo, 2021). Thus, we can infer that the COVID-19 pandemic takes on very particular characteristics in Brazil, as its synergistic aspects are revealed, even being considered syndemic, when the disease interacts with the health conditions of individuals and

the structural aspects of society (Singer; Bulled; Ostrach; Mendenhall, 2017; HORTON, 2020). In our case, the disease found a fertile environment: poverty, the inability of most of the population to keep sanitary measures, which affected the most vulnerable populations. Therefore, different knowledge and strategies must be adopted to face it. The pandemic itself is a complex socio-sanitary phenomenon and a challenge for different scientific fields, as well as for statistical education.

Therefore, it is in this scenario that we propose to reflect on how to use the context of the COVID-19 pandemic in mathematics and statistics teaching, focusing on the development of statistical thinking and literacy.

The wide dissemination of statistical information could facilitate citizens' understanding of the pandemic. However, this disclosure is also accompanied by what is called the *disinformation production process* (Brennen *et al.*, 2020; Kouzy *et al.*, 2020) because it is not news. Instead, the generation of information is deliberately fabricated to deceive people to benefit of politicians and organizations (Ireton; Posetti, 2018). The phenomenon of disinformation in several countries around the world has brought social and political consequences, such as defamation of people and election of candidates (FGV-DAAP, 2018; The New York Times, 2018). It also brought consequences for the health of the population, such as the anti-vaccine movement, which discourages people from vaccinating (Lôbo; Cazorla, 2019; Henriques, 2018). In the context of the COVID-19 pandemic, some misinformation about statistical data is being transmitted, and considering the low levels of mathematical and statistical literacy of citizens in countries like Brazil, this can seriously harm people's lives.

Another relevant issue is related to the testing procedures. If in a country the population cannot access testing, the number of confirmed cases is not recorded, so statistics may be based on underreporting. In this sense, data are more complete, as they are accompanied by the number of tests and the number of inhabitants in each country, which allows comparing the disease severity in absolute figures, as well as in relative terms (Wang; Tang; Wei, 2020).

These aspects related to the data are important to consider the context associated with the statistical data. Therefore, pedagogical situations should promote an understanding which includes how the data is generated, but also statistical meanings for figures. For example, the *lethality rate* is calculated as the proportion of infected people who died and had a positive test; this indicates the severity of the disease. In Brazil, in May 2020, for example, this rate was around 6.7%, which is considered remarkably high, whereas in the United States it is

around 5.8%, and worldwide, it is 6.6%. In August 2021, the lethality rate in Brazil was 2.8%, in the USA 1.7%, and 1.3% in India, while the world average was 2.9%. In this regard, we found that the drop in the lethality rate is due to the higher number of tests (Worldometers, 2021).

The incidence and mortality rate, on the other hand, considers the population of a country, state, or region.

An important aspect in combating the pandemic is vaccination, and, likewise, it is necessary to distinguish vaccination rates, bearing in mind that some vaccines need several doses. For this reason, we have the total doses applied (absolute value, and includes people who took all doses), the total doses per 100.000 inhabitants, the percentage of vaccinated people and the percentage of fully vaccinated people.

Representing technical data about the COVID-19 crisis immediately comes with all their dispositional aspects, as Gal (2019) mentioned when explaining the concept of statistical literacy. The data context must be part of the interpretation to ensure a critical understanding of the information provided to the citizens. Central concepts used to inform people and to motivate their behavior of social distancing and social isolation was ‘exponential growth and flattening the curve.’ In the next section, we will elaborate on how two concepts can be used in educational settings to improve people’s understanding of complex statistical information.

EXPONENTIAL GROWTH AND FLATTENING OF THE CURVE

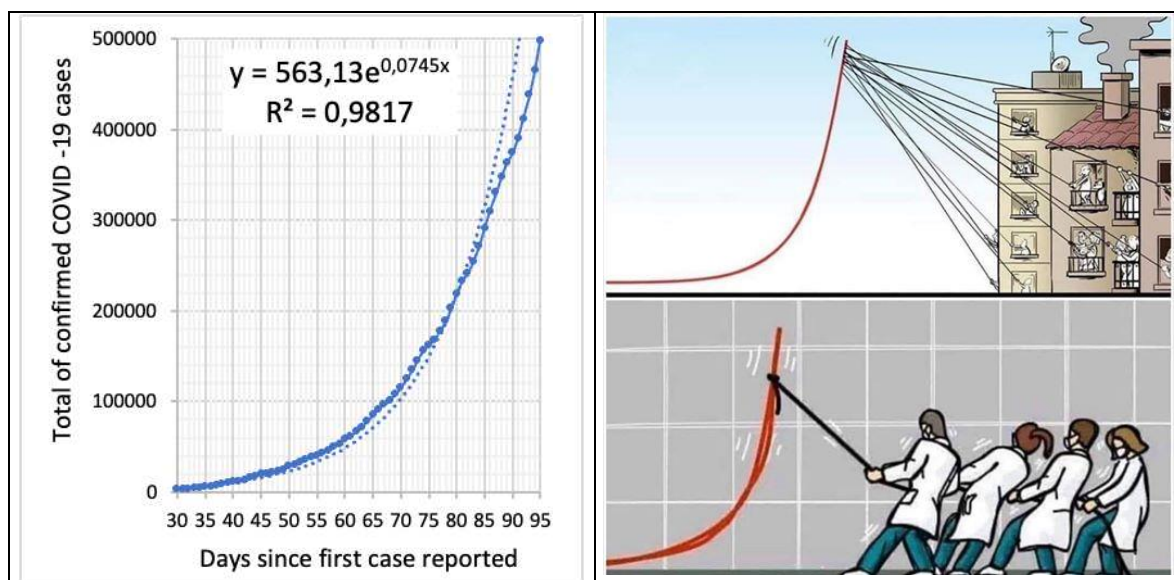
Mathematics and statistics teaching in times of crisis such as the one we are experiencing demands rethinking our approaches to contribute to education and development integrally. Mathematics teaching must educate people for democracy and peace, in a broader concept, in the sense of human rights, for a more solidary and empathic life (D’Ambrosio, 2006, 2008). One important aspect is to make strong bridges between different knowledge areas and break the isolation of mathematics as one school discipline. Studies suggested that school teachers are not prepared for interdisciplinarity approaches (Jones, 2009; Lenoir; Hasni, 2016; William *et al.*, 2016). Schleicher (2019) also suggest that interdisciplinary processes at school are complex and do not depend exclusively on teacher education but are associated with several factors such as organization and school dynamics, associated with opportunities for teachers to actively participate in school decisions, as well as teaching practice processes based on cooperative and/or collaborative practices. Even considering that the optimal conditions do not exist, situations can be proposed to encourage teachers to establish interdisciplinary practices.

The COVID-19 pandemic has been a challenge for schools to reorganize teaching approaches in different ways. This situation in which we all are involved can be an opportunity to experience interdisciplinary perspectives considering this context. However, despite the importance of considering the context, teachers from the early years of elementary school do not usually integrate aspects of statistical knowledge and context in their reflections when they report on knowledge about the content and about the student (Oliveira; Henriques, 2014). Teaching the pandemic curve and the need to *flatten* it can be an example in which teachers need to approach more mathematical and statistical concepts. It is necessary to analyze why experts and media are using this term and what are the mathematical and statistical concepts behind the representation of the coronavirus contagion rate. The teaching approach related to the “flattening of curve” should involve different concepts, such as: mortality rate, contagion rate, exponential growth, social isolation, dispersion diagram, Cartesian plane, and ordered pair.

However, the term “flattening the curve” is related to a broader context for other social and health reasons. The term comes from the need to slow down the contagion rate of infectious diseases that grow exponentially and have neither vaccines nor medicines to stop them from spreading. It is the only way to prevent the health system from collapsing.

In the context of the pandemic, mathematical and statistical information are crucial for mobilizing people to change the growing situation in the number of cases. The disclosure of quantitative data was associated with cartoons and prints that suggested that to *bring down* the growth curve, people needed to stay at home. They also emphasized the efforts of health professionals for such measures (Figure 1).

Figure 1 – Number of accumulated cases and confirmed deaths of COVID-19 in Brazil, from the 30th to the 95th day of the contamination (May 30, 2020)



Source: Brasil (2020).

The mathematical and statistical concepts of *exponential growth* and *flattening the curve* are topics which could be implemented in various ways in the curricula of institutional education (schools, teacher education); but they are also included in social media to reach all (or as much as possible) people to inform them and to motivate people to adjust their behavior of social distancing and social isolation. Well informed people with a well-developed level of statistical literacy seems to be a condition for a worldwide human environment.

PROPOSAL FROM STATISTICAL EDUCATION FOR THE INTERPRETATION OF THE COVID-19 PANDEMIC

Based on the discussion promoted in this text, on the perspective of statistical literacy (Gal, 2002; Cazorla; Castro, 2008), on critical mathematics education (Skovsmose, 1994, 2008), and on the reflections that emerged from the pandemic context, we developed strategies (actions) to address various aspects of the pandemic, extending to other contemporary cross-cutting themes (TCT), involving micro dimensions in the school, and macro dimensions in the educational system (Table 1).

Table 1 – Strategies (actions) to approach cross-cutting themes in the educational context

Strategies (actions): micro dimension	
<i>School communities</i>	<ul style="list-style-type: none"> • Develop activities with students based on information about the pandemic or other TCTs. • Engage the family and communities in out-of-school activities and projects. • Organize education cycles in schools. • Explore situations caused by the pandemic context or other TCT as a way to work the contents of mathematics, statistics, and other areas of knowledge involved. • Consider the interrelationship of synergistic aspects of the COVID-19 pandemic or other TCTs to problematize the situation in the social context.

<i>Academic communities and teacher education</i>	<ul style="list-style-type: none"> • Introduce the discussion of statistical education from the perspective of statistical literacy in the curricular components of teacher education courses (pre-service and in-service courses). • Encourage institutional programs with an interdisciplinary and cross-cutting approach to content. • Promote extension programs with activities related to statistical literacy in school contexts.
<i>Families and local communities</i>	<ul style="list-style-type: none"> • Engage the family and community in discussions about the pandemic or other TCTs and misinformation. • Offer rounds of discussion in communities. • Encourage community initiatives against misinformation, using the social resources of the territory such as groups, associations, community radios etc.
Strategies (actions): macro dimension	
<i>Educational policies and curriculum reforms</i>	<ul style="list-style-type: none"> • Foster the creation of expert groups to promote discussion and advice on curriculum reforms that provide critical empowerment and social inclusion. • Offer strategic plans to support the debate.
<i>Political pedagogical projects</i>	<ul style="list-style-type: none"> • Promote advice to education departments together with political agents in curriculum discussions.
<i>Creation of discussions forums</i>	<ul style="list-style-type: none"> • Carry out broad discussion forums on education, challenges of Brazilian education, which relate to the dimension of statistical literacy.
<i>Working groups in organizations</i>	<ul style="list-style-type: none"> • Engage statistical education organizations (e.g., Working Group on Statistical Education (GT12) of the Brazilian Society of Mathematics Education).

Source: authors

Understanding the articulation of these two dimensions and, of course, taking the pandemic as an example to be explored, we point to the contribution of critical statistical education. Those strategies advocate a sensitive critical-social humanistic approach to the teaching of mathematics and statistics that considers the knowledge of the groups, fosters the creation of new content. It helps not only to decode statistical content but builds a sensitive criticism, committed to social transformation, which will be necessary for social reorganization in a post-pandemic context.

The actions suggested can be developed with different groups and can also be the subject of discussion among education professionals who work in school communities and the academic sphere. They can also be used as an agenda of public policy managers and social movements, groups, and organizations to claim those actions in their political-pedagogical projects.

We emphasize that those strategies are possible when we consider the experiences and actions that the authors of this article have developed:

- *Statistical education and COVID-19 pandemic: possibilities of the context for statistical literacy* research project, carried out with the collaboration of elementary school mathematics teachers, involving the elaboration, realization, and publication of teaching sequences that address statistical literacy in the context of the COVID-19 pandemic;

- Course on Statistical Literacy in the Postgraduate Program on Mathematics and Technology Education attended by master's and PhD students and with the participation of national and international researchers.
- The preparation and publication of an eBook that addresses emerging themes in statistical literacy, including those related to the COVID-19 pandemic and socio-cultural situations of vulnerable populations.

Under the official documents regulating the implementation of school education in Brazil, the new curricular standards, known as the National Common Curricular Base (BNCC), propose changes for the education of young students. In this sense, the reform of high school in Brazil proposes possibilities for the teaching of statistics as an articulating axis in the implementation of the “Temas Contemporâneos Transversais [Cross-cutting Contemporary Themes] - TCT,” recommended by the BNCC, which are now considered mandatory. Moreover, the curricula are responsible for their inclusion and articulation with traditional disciplines, including mathematics, and the new disciplines implemented through the formative itineraries (Brasil, 2019a) as *a life project*.

Among the TCTs that can be explored from the point of view of statistics teaching, we highlight: Aging Process, Family and Social Life, Science and Technology, Financial Education, Work, Environmental Education, Consumer Education, Cultural Diversity, Education for the valorization of multiculturalism in the Brazilian historical and cultural matrices, Food and Nutrition Education (Brasil, 2019b, p. 13).

All those themes can be addressed both from the perspective of forming readers of the world to teach them how to collect data from official and reliable sources, as shown by Rodríguez-Muñiz *et al.* (2020) and Samá *et al.* (2020), and from the perspective of forming data producers, i.e., by formulating research questions, and from the implementation of projects that allow generating data to understand the problem, and making decisions, based on data evidence. In this sense, Giordano, Araújo and Coutinho (2019) conducted a broad survey of research that used projects in statistics teaching in Brazilian basic education. Also, teaching statistics through projects has already been recommended by researchers from the University of Granada, Spain (Batanero; Borovcnik, 2016).

Still in the wake of the development of projects in Brazilian schools, we found that there is good expertise encouraged by science fairs, in which students develop interdisciplinary and cross-cutting projects. The teaching of statistics can contribute significantly to the planning, implementation, analysis and decision-making, as shown by the analysis of the awarded projects of the Science Fair of Bahia (Cazorla; Ramos; Jesus, 2015).

Finally, this interdisciplinary and transversal perspective of approaching disciplinary content can also be addressed in the various projects of Brazilian government educational programs, such as the Programa Institucional de Bolsa de Iniciação à Docência - PIBID [Institutional Program for Teaching Initiation Scholarship] and Programa de Residência Pedagógica - PRP [Pedagogical Residency Program], which are part of the Política Nacional de Formação de Professores [National Policy for Teacher Training] and aims to induce the improvement of practical training in undergraduate courses, promoting the immersion of the undergraduate student in the basic education school (CAPES, 2021).

FINAL CONSIDERATIONS

Statistical information disclosed during this COVID-19 pandemic can be an opportunity for teachers and students to develop their *critical consciousness* (Freire, 1972) to understand and criticize statistical data related to the evolution and measures to contain the pandemic. For that, mathematical and statistical educators and researchers could contribute to problematizing the statistical literacy processes that consider the context (Gal, 2002, 2019) and associating issues that are significant for those involved in the interpretation (Ainley; Gould; Pratt, 2015; Gal, 2019). Indeed, the process of social transformation goes much further than classroom practices (Gutstein, 2003). However, the pandemic situation and the analysis of information and misinformation associated with this context can provide teaching and learning processes, in which links are made with different curricular topics that are often approached in isolation, as well as associating them with different areas of knowledge and school subjects.

People from different parts of the planet are already experiencing several crises such as those related to climate change, social exclusion processes, neofascist movements, and the relapse and increase of several diseases. Therefore, this health crisis generated by the COVID-19 pandemic is related to other factors, which made it more dramatic. For example, the correlation between COVID-19 and the consumption of ultra-processed and sugary foods with a high content of harmful chemicals increases diabetes incidence (IFD, 2019).

On the other hand, large corporations that control the food industry encourage countries such as Brazil to change healthy eating habits for a diet with ultra-processed foods and go to great lengths to avoid government regulation of the sector, thus risking the well-being of millions of people. Issues related to the protection of the environment, such as global warming and climate change, have not changed or have had little impact on industrial production in most countries. In fact, with the emergence of governments with extreme-right

tendencies, a discourse of incredulity regarding climate issues has been reinforced, one of the aspects of the so-called negationism.

Moreover, far-right governments, which preach the minimum state, have reduced investment in public education and health, easing or abandoning social assistance policies, leaving poor people even more vulnerable. For that, we can just look at the policies to combat the disease adopted by the United States, United Kingdom, and Brazil. These countries at first denied the lethality of the virus and only after analyzing scenarios such as the one published by Imperial College London (2020b), took measures to quarantine and lockdown. It is not by chance that they are at the top of the ranking of number of cases and deaths.

The elderly and those who have comorbidities are the most vulnerable populations to COVID-19, and not by chance they are mostly black, Latino, obese, diabetic, hypertensive, or poor people who do not have access to a private health service, who live on the outskirts of cities, clustered in small spaces. For most of them, “social distance” is a utopia for several reasons. The situations unveiled by COVID-19 pandemic in several countries make this biological phenomenon a social catastrophe compared to the social impact of the two great wars. Cases, deaths become numbers and, compared to other numbers (hunger, job loss, and deaths related to the social and economic crisis), there is a tendency to create a certain dichotomy between the data. What is more important about the lives lost in the pandemic or all the others that can succumb to the economic crisis? It does not seem to be an ethical choice, much less a human one.

It is necessary to rethink school education to empower teachers and students to understand, criticize, and utilize statistical information from different knowledge areas associated with problems that affect their communities. It is important to develop statistical literacy that enables citizens to read the data beyond the headlines. Students and teachers should be encouraged to question the quality of information and seek trustworthy information sources. They must know how to distinguish sources and must contend to bring down misleading information. These approaches in teaching and learning practices focused on identifying, illustrating, and understanding a complex reality promotes in students and teachers a critical understanding of social and political contexts (Aguilar; Castaneda, 2021), which is fundamental in decision-making in pandemic contexts. Developing skills associated with critical thinking requires fundamental statistical and mathematical knowledge to coexist and maintain democratic societies (Skovsmose, 1994).

Finally, it is urgent that mathematics and statistics teaching is accompanied by the promotion of values beyond the mathematical aspects and the coldness of statistics. Behind

each number of each statistical datum, there is a life, a history, a right. We all have the right to a dignified life, and it is our duty to teach mathematics for social justice and the formation of a global, solidary, and more humane community.

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