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THE TEACHING OF THE AVERAGE SPEED CONCEPT BEYOND MOTION
Problematizing the pandemic

O ENSINO DO CONCEITO DE VELOCIDADE MÉDIA PARA ALÉM DO MOVIMENTO: Problematizando a pandemia
ENSEÑANDO EL CONCEPTO DE VELOCIDAD MEDIA MÁS ALLÁ DEL MOVIMIENTO: Problematizando la pandemia

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ABSTRACT
The school environment experienced major changes after the onset of the pandemic, during which, despite the instantaneous information present in a globalized world, ignorance regarding the coronavirus still led to fallacious discourses. Thus, we aim to elucidate indicators of how the traditional teaching of a simple and frequent concept in Physics classes, average speed, can hinder clarification regarding protective behaviors against contagion. Grounded in the methodological approach of Problematization, a public sample of the population from the state of Rio de Janeiro was analyzed both quantitatively and qualitatively. The results reveal the urgency, in current High School education, for a Physics teaching approach more focused on understanding concepts.

KEYWORDS: Rate; contagion rate; death rate; High School.

Introduction

In the last decade, basic education has undergone reformulations in its operation stemming from facts, such as: the obligation to receive students with specific educational needs in regular classes; the use of the smartphone as a didactic resource in the classroom (Resende & Belizário, 2019; Kirsch, 2015); acceptance, by teachers, of results from research in education that contextualize the contribution to learning by exploring everyday situations during classes (Moreira, 2012); more recently, the use of remote classes due to the pandemic that set in at the beginning of the school year in 2020, catching a large part of the teachers unprepared regarding familiarity with technological resources to overcome social isolation.

The first cases of coronavirus in humans were isolated in 1937. However, it was in 1965 that the virus was described as coronavirus, due to its profile under microscopy, resembling a crown (*Ministério da Saúde*, 2020). As this virus is subject to mutations, the new agent, discovered in the city of Wuhan in China (Covid-19), the cause of the pandemic, was discovered on December 31, 2019, and since then has been spreading throughout the world, having its health effects minimized by the advent of the vaccine starting in the year 2021. Covid-19 presenting clinical pictures that vary from asymptomatic infections to severe respiratory conditions (Macedo et al., 2020).

The situation was elevated to an international emergency by the World Health Organization (WHO) on January 31, 2020, and on the very next day, Italy announced its first 3 cases, suspending flights from China. After 22 days, Italy had already registered 17 confirmed cases in the country.

The concern with the advance of the pandemic is mainly related to the exponential growth rate it possessed. In theory, on day 1, only one person is infected,

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but on the second day, there will be two people, on the third, four people, and on the fourth day, there will be eight infected. Thus, the behavior tends to repeat, so that after a few days, for example, after 15 days, there will be 16,384 infected (Macedo et al., 2020). This large number of sick people leads to the saturation of the health system, making care difficult, increasing the demand for resources, and facilitating the spread of the virus (Fiocruz, 2020).

Before the approval of the National Common Curricular Base (BNCC) for Elementary Education (Brasil, 2017), the concept of velocity was formally presented in the 9th grade of this level of education. Researching the term velocity in the BNCC document for Basic Education, we found that it does not appear in the area of Natural Sciences and their Technologies. Thus, we observe that the approach to the concept has changed considerably.

In the life of the common citizen and layperson in scientific matters, the term velocity appears in various situations, such as walking quickly or slowly; Formula 1 races; athletics championships; highway trips; among many others. Thus, when teaching this concept, the teacher should explore these everyday situations. This context leads us to the Problematization methodology, well-structured by Delizoicov and Angotti (1990), who emphasize that Physics should be taught to High School students in an interdisciplinary way with Chemistry, Biology, and Mathematics, and, thus, needs to guarantee a foundation of scientific education. In this sense, the apprehension of concepts, laws, relationships of Physics and their utilization should assist in bringing students closer to phenomena related to situations experienced by them, whether of natural or technological origin.

In more practical terms, the Problematization methodology is divided into three moments, defined as Three Pedagogical Moments, which are: 1) Initial Problematization, in which a problem anchored in reality is presented to the students so that they relate it to the concepts of the school disciplines, in this case, that of Physics; 2) Organization of knowledge, defined as the moment in which the necessary knowledge for understanding the intended theme is addressed, such as the concept of average velocity; 3) Application of knowledge, which systematically addresses the content that has been incorporated by the student to analyze and interpret their daily life (Delizoicov *et al.,* 2002).

In this work we will consider the third highlighted point: exploring the everyday to address the concept of average velocity, one of the first physical concepts to be formally presented to young people.

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As a summary of the text, the research question consists of: how can the traditional teaching of the concept of average velocity make it difficult to extrapolate beyond movement? To explore this question, we will seek to understand protection behaviors during the pandemic, especially when discussing contagion and mortality rates in the 2020 to 2022 pandemic. The authors seek to investigate whether Physics teaching, focused only on the application of formulas and the movement of bodies, adequately prepares students to interpret epidemiological data and make informed decisions in real everyday situations, such as the Covid-19 pandemic.

The research objectives are, first, to analyze the understanding of the average velocity concept among different age groups and educational levels, verifying whether participants can extrapolate this concept beyond physical movement, relating it to contagion and mortality rates. To this end, a public questionnaire was administered, which sought to identify not only the theoretical knowledge of the formula but also the abilitydos entrevistados de aplicar o concept in everyday and social contexts, such as the spread of diseases. Thus, we can define that based on the data obtained from the public sample, the data was treated in a quali-quantitative manner.

Furthermore, the questionnaire's questions aim to highlight a more problematizing methodological approach in the teaching of Physics, using the Three Pedagogical Moments, thereby creating a dialogue about the need to promote critical and contextualized learning. When discussing the results, the authors show that many interviewees still have difficulty in extending the concept of average velocity to other phenomena, which reinforces the urgency of rethinking Science teaching to train citizens capable of interpreting scientific information and combating fallacies, especially in situations of health crisis.

Problematization Methodology and the concept of average velocity in the pandemic

The methodological approach of Problematization through the Three Pedagogical Moments was proposed by Delizoicov and Angotti (1990) and also investigated by Delizoicov, Angotti, and Pernambuco (2002), during the teacher training process in the Guinea-Bissau region, originating from the transposition of Paulo Freire's (1987) conception to a formal education context, which emphasizes a dialogical education, from which Moreira understands that:

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Studying requires appropriation of the meaning of the contents, the search for relationships between the contents and between them and historical, social, and cultural aspects of knowledge. It also requires that the learner assumes themself as the subject of the act of studying and adopts a critical and systematic posture (Moreira, 2014, p.4).

A fact capable of contributing positively to the idea that: "teaching is not transferring knowledge but creating possibilities for one's own production or its construction" (Freire, 2005, p.47).

Corroborating the ideas of Delizoicov, Moreira, and Freire, we consider pertinent the teaching/study of the concept of average velocity problematized as the contagion velocity of Covid-19 (Coronavirus Disease). Thus, the concept of moving average was popularized in the context of the new coronavirus pandemic. The moving average is an indicator that was used to assess the trend of the pandemic's behavior. Through the analysis of the moving average, it was possible to perceive when the number of cases was growing, decreasing, or stabilizing and, indeed, it was important data conveyed by the news during the pandemic (Moraes, 2021).

During this period, some of the following fallacious statements were recurrent on social media: "cigarettes, heart attacks, or dengue kill more than Covid"; "H1N1 killed more people than Covid and no lockdown was imposed". These ideas appeared in short and poorly explanatory sentences to promote resistance by the population against the health measures that restricted urban mobility and established safety protocols such as social distancing and the use of masks.

The concept of rate allows evaluating the veracity of each of these affirmations, since to compare the effects of one disease with another it is necessary to compare the incidence of cases and the number of deaths in the same time interval. It is necessary to evaluate, for example, whether the number of deaths caused by H1N1, in one year, is of the same order of magnitude as that number caused by Covid, also in one year.

It is possible, furthermore, to evaluate the effects of the pandemic by comparing the average number of deaths by Covid with the average number of deaths caused by all other causes of death before the pandemic. In this sense, it is possible to find reliable data to support these analyses in epidemiological bulletins produced by the Unified Health System (SUS), but these devices are not disclosed by the media and, furthermore, were not linked to those messages viralized on social networks.

Through all these considerations, we understand that the concept of rate can be explored in the classroom by means of analogies with the concept of average velocity.

Analogies of this nature allow for the development of interdisciplinary themes and provide opportunities for Science Education to fulfill its social role, by providing the individual with tools to understand and interpret the reality in which they are inserted.

Ultimately, these discussions allow the individual to evaluate news, information, and conversations so that they can make the most balanced and appropriate decision to safeguard their health, preserve their families, and carry out daily activities with the maximum safety that their economic and social condition permits.

The Three Pedagogical Moments of Delizoicov and Angotti (1990) will be worked on based on data from a random sample, in which we want to discuss the concept of average velocity and the pandemic that was occurring, and verify the indication of the need to problematize knowledge more, in relation to popular fallacies cited earlier.

In this sense, we investigated the knowledge of the concept of rate and the ability to apply this concept in everyday situations through a questionnaire that was applied to a group of 208 people. In it, we brought to reflection the perception of how the concept of average velocity, rarely, is commented on referring to the rate of variation of a quantity in relation to time, which would be essential to understand the complexity of the numbers in the context of the pandemic.

Average speed, rate, and diseases: an interesting relationship to problematize

First of all, it is necessary to present, in summary form, the relationships and definitions that served as a common thread to construct the entire questioning of this text. The first important concept is that of average velocity. We know that average velocity is a physical quantity that calculates the rate of variation of an object's position in relation to time. Strictly speaking, it is a vector physical quantity, however, we will treat it in a scalar form as a synonym for speed. In this way, we present equation (1), well-known in Physics teaching at the high school level.

$$V_{avg} = \frac{\Delta S}{\Delta t} \quad (1)$$

In which ΔS is the variation of the scalar position (displacement) along the trajectory and Δt is the variation of time (time interval), being then defined based on the displacement of a material point (Gaspar, 2016). We know that the most well-known units of velocity are the kilometer per hour (km/h) and the meter per second (m/s), or rather, a unit of the quantity displacement (length) divided by a unit of the quantity time.

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The speed of light (approximately 300,000 km/s) and the speed of sound in air (approximately 300 m/s) are well-known examples in the scientific community. Furthermore, it is common to see and hear information about speed limits in traffic, heart rate limits, and even the time limit we can sleep so as not to arrive late for work, depending on the average velocity reached on the home-work commute.

We can think that velocity is the "speed" with which an object performs a displacement, covers a distance, and we simplify the understanding of equation (1) through equation (2), that is, to cover a certain distance, it will take a certain amount of time.

$$Velocity\ \ of\ \ an\ \ object = \frac{d\left(distance\ \ traveled\right)}{t\left(time\ \ taken\right.}\ \ travel\ \ distance\left.\right) \quad (2)$$

As we have seen, average velocity is defined as the ratio between the displacement of an object and the time interval in which this displacement occurs, being a vector quantity that indicates not only the value, but also the direction of the movement. On the other hand, average speed corresponds to the magnitude of the average velocity, that is, it represents only the absolute value of the rate of change of position, without considering the direction. In basic education, especially in situations of rectilinear motion, speed and average velocity are often treated as synonyms, as both express "how fast" something happens.

However, it is important to note that, while velocity can take positive or negative values depending on the direction of displacement, speed is always positive. Everyday examples help illustrate this difference: when driving a car, the speedometer indicates the speed, showing only the absolute value of the velocity, regardless of the direction; when calculating the average velocity of a trip, the total displacement and the time spent are considered, and the value can be positive or negative depending on the route. In sports, for example, in a 100-meter dash, an athlete's average speed is obtained by dividing the distance covered by the time spent, without considering direction, whereas the average velocity could be negative if the athlete returned to the starting point.

In broader contexts, such as in the analysis of disease spread, one may refer to "contagion velocity" or "dissemination rapidity," applying the concept of rate beyond physical motion. In this way, understanding the distinction between average velocity and rapidity allows for a broader comprehension of phenomena beyond physical movement, promoting an interdisciplinary and contextualized approach to science education. It is this expansion of the concept of velocity that we will now address.

With equation (2) in hand, we move on to the concept of rate, which is a relationship established between two quantities. According to the online dictionary of According to a Portuguese dictionary consulted in 2020, we have the following definition of rate: “[Mathematics] A ratio, in a relationship between two quantities, in which the first is dependent on the second.”

We can generalize the concept of rate as the ratio between any two distinct and dependent quantities, which represent physical phenomena, “A” and “B.” In the case of equations (1) and (2), in the International System of Units, it would be the amount of meters traveled by an object over the course of 1 second, which represents the rate of change of position. Thus, we can write equation (3), in which the rate of rapidity of a phenomenon is defined by the ratio between a generalized quantity A(t) and time:

$$Rate \ \ of \ \ speed = \frac{A(t)}{t} \tag{3}$$

An interesting presentation of the idea of rapidity is defined by Biscuola et al. (2016) in the book Physics 1 (Mechanics), in which it is stated that average rapidity can be equated to the term average velocity, symbolized by Rapm, and they write the following formula:

$$Rapm_{\square} = \frac{d}{\Delta t} \tag{4}$$

This formula represents a valuable initiative by the authors of a high school physics textbook to broaden the definition of velocity as it relates to any phenomenon with temporal dependency. Through this relationship, students could more easily understand other concepts within physics itself, such as velocity rapidity as acceleration, liquid flow rapidity as flow rate, heat rapidity as conduction, and charge rapidity as electric current.

Now moving into the context of a pandemic, we can assume that A(t) represents the number of infections or deaths related to a given disease (such as Covid-19, or simply coronavirus) occurring over a period of timeΔt.

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Thus, we obtain the rapidity of contagion or the mortality rate of the disease, calculated by equation (5).

$$Rate\ \ of\ \ contagion(death)=\frac{Number\ \ ofcontagions(deaths)}{\Delta t} \quad (5)$$

Equation (5) represents an expansion of the concept of “speed” which can be explored in physics education, going beyond the idea of motion. From this perspective, we can design an activity in which students estimate the “velocity” or rate of disease progression using official data produced by federal government agencies, thereby contributing to the social dimension of physics education.

The contribution of science education in these activities provides opportunities for a deeper understanding of disease spread and, in turn, helps combat misinformation.

It is well known that during the pandemic, there was a surge in the spread of false ideas, often conveyed through simplistic or misleading phrases.

Let us examine a common fallacy: “Smoking, heart attacks, and dengue kill more than Covid.” Statements like this are misleading, as they fail to account for the number of deaths occurring within a short time frame due to an infectious disease. The causes of both phenomena are not comparable, and the intersection of data and public health measures must be specific to each situation.

The common error found in these ideas arises from the lack of comparison between the temporal evolution rates of each disease and the disregard for the average velocity with which the phenomena of contagion and death propagate.

In Brazil, in just three months (considering March, April, and May of 2020), Covid-19 reached 300,000 reported infections and more than 22,000 deaths. Based on these data, the rate or velocity of contagion would be 100,000 per month, while the mortality rate would be 7,333 per month.

When the same analysis is applied to Dengue, for example, it is possible to obtain, from epidemiological bulletins (Ministry of Health, 2019), a contagion rate of 5,778 cases per month and a mortality rate of 20 deaths per month. These figures closely reflect monthly periods from the year 2019. In this way, one might suggest that Dengue could be equated with Covid-19.

Table 1 presents a comparative analysis of other diseases affecting the Brazilian population and serves to broaden the discussion on contagion velocity and recovery velocity.

Against the lack of extrapolation of physics into life or beyond mere interpretation of the world, problematizing pedagogy offers a path forward—one in which schools can foster critical and curious thinking in students, rather than passive acceptance of available knowledge. Learning occurs through the formulation and reformulation of knowledge using practical examples. Physics must be taught in this way, as its practice is also a learning process—both are tools of the subject in the learning journey.

However, this scenario in formal education is challenging, given that Freirean theory, which proposes education from this perspective, was essentially developed from informal education. Within the dialectic and the pandemic context, Freire's ideas for daily classroom activities, as presented by Delizoicov (1991, 2005), suggest the use of three pedagogical moments: (i) - Initial problematization to foster discussion about velocity beyond motion, such as velocity related to rate and the speed of contagion and death from any given disease; (ii) - Knowledge organization to explain the meaning of rate and its direct relationship with rapidity and velocity; (iii) - Knowledge application to present data on Covid-19 and other diseases.

Table 1

Contagion velocity and mortality rate of some diseases in Brazil

Disease	Contagion speed (infections/month)	Mortality rate (deaths/month)	Time interval considered (months)
Sarampo	1.667	0	3 (2019)
Chikungunya	12.271	10	48 (2015 a 2019)
Dengue	5.778	22	9 (2019)
Febre Maculosa	167	3	12 (2018)
Influenza	567	117	12 (2018)
HIV	3.588	208	12 (2017)
COVID-19	100.100	7.333	3 (March to May 2020) *
COVID-19	1.083.333		12 (March 2020 to March 2021)

Note: Epidemiological Bulletin - Health Surveillance Secretariat in Brazil. Ministry of Health (2019).

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Note: Ministry of Health Report of 06/01/2020.

Methodology

The research methodology consists of data collection through a public survey, conducted via a questionnaire on Google Forms. The link generated by the Google Form was shared on social media and in instant messaging app groups by the authors. Table 2 presents the questionnaire questions along with their respective objectives. The form was available online from May 20 to May 31, 2020. During this eleven-day period, a total of 208 responses were recorded.

Table 2

Questions asked via Google Forms and their objectives

QUESTION	OBJECTIVE
1)Do you remember the definition of average velocity given by the formula v = ΔS/Δt, where ΔS is the change in position (displacement) and Δt is the time interval during which the distance was covered? YES or NO	Verify whether the person remembers the theoretical formula for average velocity. If the person answers "Yes" they are directed to question 2. If the person answers "No" they are directed to question 3. First pedagogical moment.
2)Do you remember at which educational level you first saw this definition of average velocity? PRIMARY SCHOOL or SECONDARY SCHOOL or HIGHER EDUCATION or INFORMAL EDUCATION	Verify at which educational level the person remembers having studied the theoretical definition of average velocity.
3) In the Aurélio online dictionary we have the following concept of RATE: [Mathematics] Ratio, a relation between distance and time, not tied to direction. DO YOU KNOW THE RELATION BETWEEN RATE AND VELOCITY? YES or NO	Verify whether the person knows the relationship between rate and velocity, something beyond the theoretical teaching of average velocity and limited to motion-related questions. If the person answers "yes" they will be directed to question 4. If the person answers "no" they will be directed to question 5. First and second pedagogical moment.
4)Do you remember at which educational level you first saw the relation between rate and average velocity? (velocity as the rate of change of a body) PRIMARY SCHOOL or SECONDARY SCHOOL or HIGHER EDUCATION or INFORMAL EDUCATION	Verify at which educational level the person remembers the relationship between average velocity and rate.
5)Do you think it is important to know the concept of average velocity and rate of change to understand COVID-19 and the	Verify whether the person can relate the concept of average velocity tied to motion to the idea of infection rate and death rate in the

difference between infection rate and death rate? YES or NO	case of a disease. Third pedagogical moment.
6)WHY?	Optional question that seeks to verify the set of words related to the answer given in question 5. Third pedagogical moment.

Note: The authors (2021).

The public consultation had two inclusion criteria for the research, which were stated in the introductory text: being a resident of the state of Rio de Janeiro and having completed elementary education. In the process of collecting personal data, following the initial presentation, we asked participants about their age, place of residence, and level of education (completed elementary education, secondary education in progress or completed, higher education in progress or completed, and postgraduate studies in progress or completed).

Questions regarding education level and place of residence were used to confirm the inclusion criteria. The personal data collected did not include names and were intended to identify trends, not individuals. The form was available online from March 24 to March 31, 2020. During this period, a total of 208 responses were recorded.

A convenience sampling method was used, with participants recruited through social media and groups representing residents of the state of Rio de Janeiro. The aim was to understand individual experiences and to enable both descriptive and generalizing analyses. For this purpose, participants were divided into two age groups: 14 to 39 years and 40 to 80 years.

The study adopted a mixed-methods approach, combining quantitative and qualitative data. According to Minayo and Sanches (1993), even when a study does not adhere to a specific perspective, it can still integrate both approaches, as long as it maintains the coherence of each.

The relationship between quantitative and qualitative approaches, between objectivity and subjectivity, is not a continuum and should not be seen as contradictory. On the contrary, it is desirable that social relations be analyzed through both "ecological" and "concrete" lenses, deepening their meanings in more essential ways. Thus, the quantitative aspect can offer descriptive and generalizing analyses, and vice versa (Minayo & Sanches, 1993, p. 247).

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In this sense, we can say that the quantitative approach provided indicators and observable outcomes, while the qualitative approach offered insights and meanings (Minayo & Sanches, 1993).

This methodological construction seeks to draw a parallel with the Three Pedagogical Moments, through which the public consultation was conducted. To justify the use of digital tools in this process, we note that in Brazil, 69.9% of households had internet access as of 2018; among individuals aged 10 and older, 57.8% used the internet, and 56.6% used microcomputers (IBGE, 2018).

The expansion of the internet has become a strong environment for scientific research, as emphasized by Fragoso, Recuero, and Amaral (2013), given the power of the internet as a research object and the fact that it has become the space where research is conducted.

From a problematizing perspective, we developed questionnaires that could be used at any time and that would serve as a good starting point for gathering opinions that were not deeply explored by other authors (Albuquerque et al., 2015) or, in our case, by former students. These individuals were invited to reflect on a previously experienced concept, generally seen, generated, and transformed during their academic training and applied to their daily lives.

In this context, a questionnaire was created with questions aimed at gathering a wide range of opinions, both from current students and former students, in order to collect data that would help reveal experiences lived during their academic training.

In Brazil, ethical oversight of research is handled by the National Research Ethics Commission (Conep), which is linked to the National Health Council (CNS) and was established by Resolution CNS No. 196/1996. Among Conep's responsibilities, Resolution CNS No. 466/2012 revoked Resolution CNS No. 196/1996 and approved "[...] guidelines and regulatory standards for research involving human subjects" (Brazil, 2013, p. 59). Resolution CNS No. 510/2016, in turn, addresses:

> [...] applicable norms for research in the Human and Social Sciences whose methodological procedures involve the use of data directly obtained from participants or identifiable information that may pose greater risks than those encountered in everyday life" (Brazil, 2016, p. 44).

Even though Resolutions CNS Nº. 466/2012 and Nº. 510/2016 are not mandatory for research in the fields of Human and Social Sciences, these regulations focus on

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safeguarding research participants and do not take into account the specificities of online research. Regardless of the existence or absence of an ethical regulation system

In online research, at the beginning of the public questionnaire, we informed participants that the data would be used for research purposes, in the format of a digital informed consent form. Although aware of the impersonal nature of the internet, this measure serves to protect both researchers and participants, ensuring the integrity of the research process and the individuals involved, whether in physical or online environments.

Strict anonymization practices were adopted to safeguard participants' identities. The data collected through the public questionnaire did not include personally identifiable information such as names or documents, ensuring that responses remained anonymous throughout the analysis process. It is important to note that all information was securely stored with restricted access. Additionally, the researchers were meticulous in protecting the data and preventing any risk of improper exposure. Informed consent was obtained digitally, clearly informing participants about the use of their data for scientific purposes and reinforcing the ethical commitment of the research.

Results

The mathematical concept of average scalar velocity is defined as the division of scalar displacement by the time interval in which it occurred. However, starting from this notion of the rate of change in position, we arrive at a definition that no longer pertains to movement itself, and the idea of Average Velocity or Speed can be extended to estimate the rate of contagion and mortality during a pandemic.

At the historical moment in which Brazil faced a global pandemic, with serious consequences such as more than 600 thousand deaths and millions of infected individuals, understanding the rate of contagion and mortality became essential. Thus, we present an approach that helps citizens use the concept of rate or speed to understand the calculation of the contagion (or death) rate based on the information available at the time. Based on this, we conducted a study with a sample of

Let us now analyze the results of this research.

Based on the distribution of age data from the sample, as shown in the histogram of age ranges (Figure 1), we chose to divide the subjects into two groups: Group A – ages 14 to 39; Group B – ages 40 to 80. By summing the areas of the histogram ranges for Group A, we can see that it is approximately equal to the area of the ranges for Group B.

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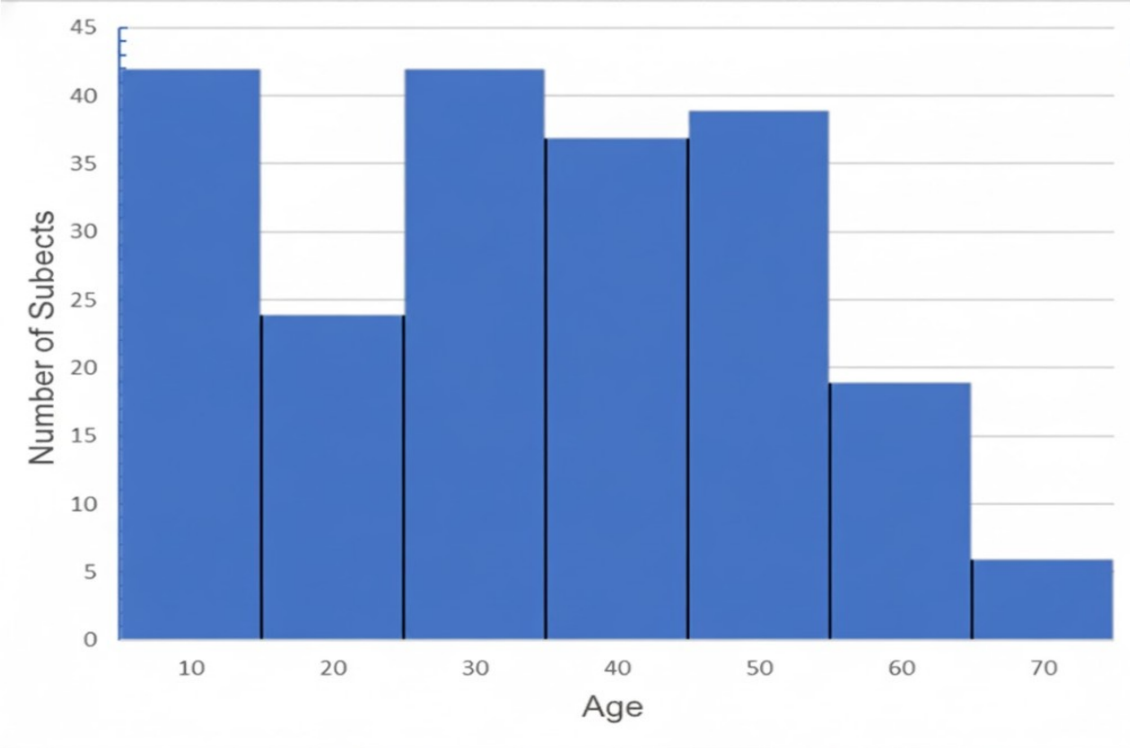
Thus, we have two groups, each representing close to 50% of the sample, from different generations, allowing us to compare their understanding.

Figure 1

Histogram of subjects by age group

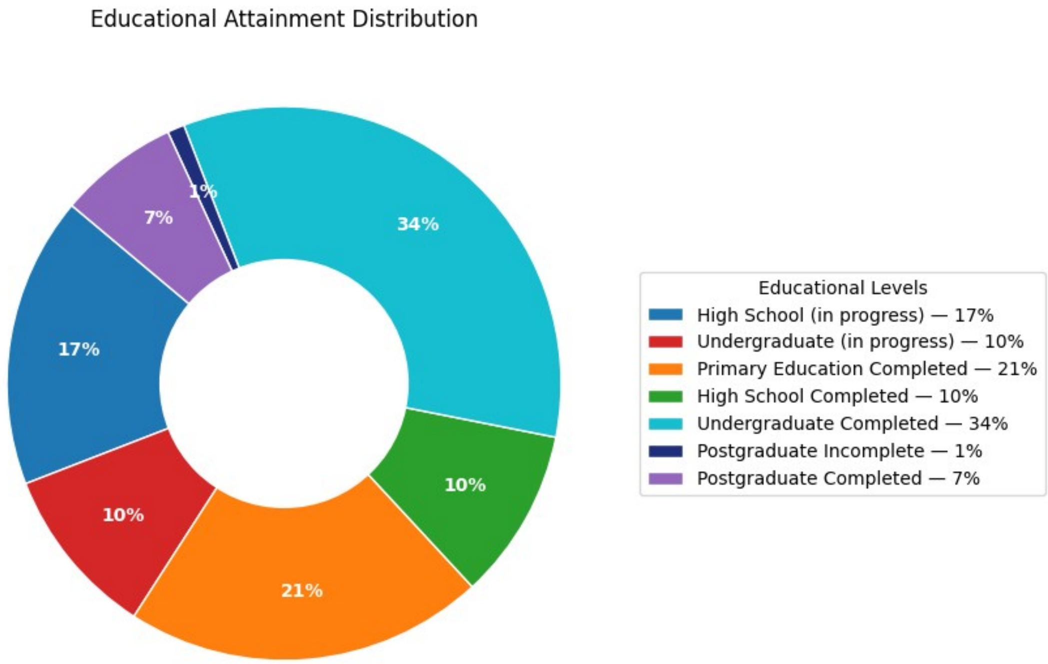


Note: The authors (2024)

Of the 208 respondents, 89% were from the metropolitan region of the state of Rio de Janeiro, specifically from the cities of Niterói, São Gonçalo, Rio de Janeiro, Duque de Caxias, and Itaboraí; 10% were from other municipalities within the state of Rio de Janeiro; and 1% (2 individuals) were from other Regarding the distribution of educational levels, as shown in Figure 2: 17% are currently attending high school; 62% have completed higher education, with 21% holding only an undergraduate degree, 34% having completed postgraduate studies, and 7% with incomplete postgraduate studies; only 2 individuals, or 1%, have completed only elementary education; 17% are currently attending high school; and 10% have completed only high school. This indicates that most respondents—62%, as previously mentioned—have completed higher education.

Figura 2

Distribution of subjects by educational level



Note: The authors (2024).

Regarding undergraduate education, participants were asked whether their focus had been in the humanities or in the exact sciences: 68% (90 individuals—49 with postgraduate degrees and 41 without) reported a focus in the humanities; 31% (41 individuals—23 with postgraduate degrees and 18 without) had studied exact sciences. The data show

Most respondents graduated with an emphasis in the humanities, meaning the topic of velocity was studied during elementary and secondary education.

Regarding postgraduate education, 72% of participants had completed postgraduate studies, distributed as follows: 61% held a specialization degree; 25% had a doctorate; 10% had completed an academic master's degree; and 4% had completed a professional master's degree.

From these results, it is worth noting that among those with postgraduate education, 35% pursued the academic track and 65% followed the professional track, with 61% being specialists and 4% holding professional master's degrees.

According to the sequence of questions presented in Table 2, the first question asked was about the velocity formula—the classic average velocity formula (Equation 1).

In Group A, 80% reported remembering the formula. In Group B, however, the recall rate dropped to 55%. On the other hand, the percentage of individuals who did not remember the average velocity formula was 16% in Group A and 45% in Group B.

This reveals that Group B, composed of older individuals within the sample, experienced a more technical education in science, where scientific literacy was less emphasized. Group A, by contrast, reflects a more formal science education.

The technicist trend became established in the 1970s, grounded in the principles of optimization: rationality, efficiency, and productivity. With its rational and mechanical organization, it aimed to align with the interests of industrial society. The resemblance to industrial processes is no coincidence, as this approach reached its peak in the 1970s—a period marked by strong authoritarian presence from the State and the military regime (Filipaki, 2010, p. 4–5).

It was during this time that critical and reflective thinking was removed from schools, a period that coincides with Group B, composed of individuals over 40 years old.

In the 1980s, education became more focused on preparing individuals for the job market, as there was no clear professional direction. According to Frigotto and Ciavatta (2006), Law No. 5692/71 (Brazil, 1971) introduced a dual-purpose model for technical education at the high school level. The discourse used at the time highlighted the scarcity of technical professionals and the need to address the frustration of young people who were unable to enter the workforce due to the lack of professional qualifications.

This issue was addressed through the concept of "terminality" in Technical Education (Frigotto & Ciavatta, 2006, p. 36). Only with the Law of Guidelines and Bases (LDB) (Brazil, 1996) did the coexistence of high school and technical education return, allowing students to receive both general and professional training. This shift helps explain the greater familiarity with the velocity formula among participants under 40 years old.

Question 2 states that, according to the Aurélio dictionary, the concept of "rate" is defined as a ratio between two quantities, where the first depends on the second. Based on this, we asked: "Do you know the relationship between rate and average velocity?"

Interestingly, this question revealed no significant difference between Groups A and B (Figure 3).

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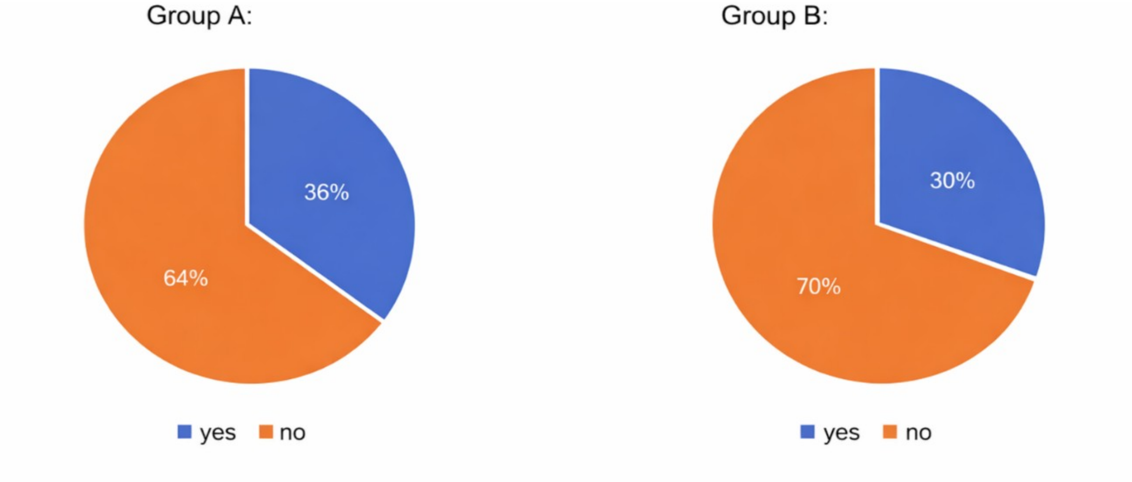
Figure 3

Distribution of knowledge about the relationship between rate and velocity in Groups A and B



Note: The authors (2024).

Velocity is not merely associated with movement, but rather with the idea of a temporal rate of change in position. In Group A, 64% recalled this concept from their education, while in Group B, the percentage rose to 70%. It is interesting to observe that some individuals equate velocity with speed, even though they are not entirely synonymous. Velocity refers to a temporal rate, whereas speed is simply the magnitude of displacement over time.

When asked whether velocity and speed were taught as similar concepts in school (Figure 3), responses varied. According to Table 3, 42 individuals from Group A recalled learning about the relationship between velocity and speed in middle school, while 39 from Group B did the same. In high school, 45 individuals from Group A and 55 from Group B remembered this relationship, indicating that participants from both groups had exposure to the concept starting from elementary education.

We observed that most of the 45 respondents from Group A had either completed or were currently attending high school, indicating that younger individuals answered that they had learned the formula in elementary school. It is common for this formula to be briefly introduced at the end of that educational level. In high school, velocity is one of the first concepts taught in physics and is addressed throughout the curriculum, as it is a key topic in mechanics and essential for understanding most of the content.

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In summary, the different generations represented by Groups A and B reflect the historical and pedagogical changes in science education in Brazil. The dominant attitude in Group B, in recalling the formula for average velocity, is attributed to a technicist teaching approach prevalent during the 1970s and 1980s, characterized by an emphasis on rationality, efficiency, productivity, and the suppression of critical and reflective thinking.

As a result, most participants—especially those in Group B (older individuals)—associate the concept of average velocity solely with the traditional formula taught in schools, without being able to relate it more broadly to other contexts. This limitation is precisely the core issue of theoretical foundation and philosophical purpose, recognizing that average velocity goes beyond physical movement and can be understood as a rate of change of any quantity over time.

To meaningfully integrate these concepts, activities may include: analyzing epidemiological data to calculate the velocity of disease spread and mortality rates; constructing and interpreting graphs to show the evolution of cases; debates about fake news using rate calculations to verify common claims; classroom simulations of disease propagation; and interdisciplinary studies of real-world events, such as the impact of social isolation.

These activities promote contextualization, critical thinking, and interdisciplinary learning, helping students understand the concepts of velocity and rate across different fields—especially in public health.

It is also interesting to note that some individuals, though not many, among the three items in question two and the new item in question two, relate the formula to their educational background and understanding. On the other hand, it is known that most respondents had completed high school, which may reflect their exposure to this level of education, even if they are no longer actively studying. The formula and its meanings are often introduced at the end of elementary school and reinforced throughout high school.

Tabela 3

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Percentage distribution of subjects who answered YES to questions 1 and 2 by the educational level they were in.

Educational level	QUETION 1 Group A	QUESTION 1 Group B	QUESTION 2 Group A	QUESTION 2 Group B
Primary	50,0%	26,8%	20,5%	16,7%
Secondary	46,7%	69,6%	64,1%	60,0%
Higher	1,1%	1,8%	7,7%	3,3%
Informal	2,2%	1,8%	7,7%	20,0%

Note: The authors (2024).

According to the frequency shown in Table 3, the response "yes" to the second question reveals that most of the groups remembered the speed formula learned in high school. This data shows a strong connection between high school education and the ability to recall the formula. In contrast, the number of people who said they did not know this relationship is: 69 affirmative responses to the second question and 146 to the first question.

In the third stage of the Problematization process, participants were asked to find connections between the concepts addressed—not only through definitions, but also through phenomena that could establish a link with real-world information. This encouraged a questioning attitude, raising issues that needed to be considered in everyday life, and served as a good moment to reflect on concepts that had not been previously addressed.

In the third question, participants were asked whether they considered it correct to speak of velocity of contagion and velocity of deaths in relation to Covid-19. We observed that the majority, regardless of age, answered yes (75% for Group A; 76% for Group B). It is interesting that, although velocity is not typically associated with a temporal rate of any phenomenon, this connection is understandable due to the rapid spread of the virus When discussing disease (a problematization of the concept of velocity), participants were able to relate the speed of contagion to a temporal rate.

Due to the methodological approach of the Three Pedagogical Moments, which aims to foster dialogue between researcher and participant, all questions valued

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spontaneous conceptions, assessing to what extent individuals have an expanded worldview regarding the pandemic.

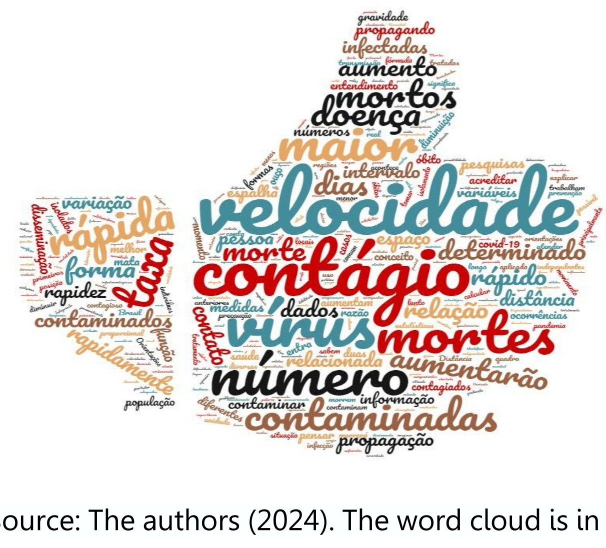
In the case of velocity related to the number of infections and deaths, participants were invited to comment, though it was not mandatory. Elements extracted from these comments are rich sources of information on how the problematization of knowledge is organized within each individual's worldview, since the act of writing requires a less immediate, more reflective response, encouraging participants to refine their thoughts (Oliveira & Carvalho, 2005; Francisco Jr., 2007).

Based on the responses, we created word clouds. The cloud generated from the 155 “yes” answers (Figure 4) reveals a strong relationship between the words contagion, number, and speed—indicating that a higher contagion rate (velocity) implies an increase in the death rate (velocity).

This interpretation is evident in the analysis of the “yes” responses, which show that participants associated the concept of average velocity with the speed of death or contagion. They also connected it to terms such as increase in infected individuals and increase in velocity, demonstrating an expanded understanding of the concept of velocity—often limited to physical movement (Table 4).

Figure 4

Cloud of the 155 "yes" responses to the question about the possibility of speaking of the rate of infections and deaths of a disease.



Note. Source: The authors (2024). The word cloud is in the original Portuguese. The most prominent terms translate as: *velocidade* (speed/velocity), *contágio* (contagion), *vírus* (virus), *mortes* (deaths), and *número* (number)

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Table 4

Examples of the "yes" responses.

"Because we are measuring how long it takes for something (deaths, infected) to occur."
"Yes, because there is a variation in deaths, for example, as a function of time."
"The speed of contagion increases the proportional number of dead."
"I think of the rapidity of contagion or of the increase in the number of deaths."
"Because I believe that although it does not involve the dimension of distance, we have two variables that grow, such as the number of infected people and time, which depending on the place can be faster or slower."

Note. the authors (2024).

In the case of the word cloud from the 53 'no' responses (Figure 5), we notice—especially through reading the answers (Table 5)—many expressions such as space, time, and distance traveled. In other words, there is a difficulty in expanding the concept of velocity; people show limitations in understanding the concept of motion and a need to broaden the concept beyond movement itself, an emerging problematization for everyday clarification in the context of a pandemic.

Figure 5

Cloud of the 155 "no" responses to the question about the possibility of speaking of the speed of infections and deaths of a disease.

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Note: Source: The authors (2025). The word cloud is in the original Portuguese.

The most prominent terms include: Mortes (Deaths), Contágio (Contagion ou spread), Número (Number),Espaço (Space),Taxa (Rate),Vírus (Virus), Distância: (Distance),Depende ((It) Depends), Contaminação (Contamination), Doença (Disease), Infecção (Infection)

The clouds represent a visual method, aided by the idea of frequency, to observe all responses collectively. In general, most participants were able to relate velocity to contagion rate, death rate, and the increase or decrease of these numbers as a direct implication.

As a final reflection, Physics Education has often been carried out through the presentation of concepts, laws, and formulas in a disconnected and outdated manner, distancing itself from the lived experience of reading the world and leading to empty and meaningless interpretations, shaped by the pandemic context we are living in.

Consequently, Physics Education in Basic Education has been reduced to a frustrating task of formula memorization, aimed solely at problem-solving. On the other hand, Problematization—beyond being content-related—can place Physics within contemporary education as a less mechanized and more contextualized learning experience.

Table 5

Examples of the "no" responses

"Because contagion and death are point events, not continuous."
"The correct thing would be to speak of the rate of infections and deaths."
"Not everyone who has contact with the virus is led to death."
"Velocity is a physical concept.."
"Since velocity is distance traveled in a given time, we cannot state what distance would be traveled by a virus."
"I would not count deaths using the concept of velocity."
"Velocity is related to time and distance."

Note: The authors (2024).

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Final Considerations

Faced with the guiding question of this research—how traditional teaching of the concept of average speed can hinder its extrapolation beyond physical motion—the results presented in the article indicate that traditional instruction of average speed may indeed limit its application to contexts beyond physical movement. This is mainly due to the way the concept is formulated and taught, which restricts students' understanding and their ability to apply it to real-world situations where movement is not necessarily physical. Many participants, especially those with more consistent engagement, associate average speed solely with the relationship between space and time, without being able to extend the concept to other phenomena, such as contagion or mortality rates in diseases.

This limitation is evident in the difficulty respondents had in recognizing that average speed could be used as a rate of change of any quantity over time. While most were able to relate it to physical motion scenarios, few could connect it to social or biological situations, such as the spread of diseases.

The findings suggest that, to overcome these challenges, it is necessary to adopt teaching approaches that promote problematization and contextualization of content, bringing it closer to real and meaningful everyday situations. Activities such as the analysis of epidemiological data,

The construction of graphs, debates about fake news, and simulations of disease spread can promote an expanded understanding of average speed as a rate, making Physics teaching more relevant and meaningful for civic education.

In the presented context, during the pandemic period we saw the proliferation and dissemination of narratives containing information about the mortality rate of Covid-19 compared to other well-known diseases. From March to June 2020, in many Brazilian states social isolation was decreed due to the high transmission speed of the new coronavirus (SARS-CoV-2). Despite the numbers and data provided by the Ministry of Health, we lived with the spread of fallacies and false news (fake news).

During the course of this work, we debated the urgent need to find pathways to an education that can be felt in practical applications, constantly engaging with Science in a clear and didactic way that can contribute to reflections on different natural phenomena and consider the concept of velocity beyond the movement of a body. The published research that will be evaluated in this work presents as one of its central axes the idea of velocity, which involves speed.

It is clear that the Teaching of Natural Sciences (Physics, Chemistry and Biology), particularly Physics Teaching, according to the BNCC, should ensure that investigative competence is developed in the student. In order to meet these ideas, we sought to work on the concept of velocity using the methodological approach of the Three Pedagogical Moments as a means of teaching the concept of velocity differently to students, problematizing and contextualizing situations such as Covid-19 to broaden their worldview and prevent fallacies that can harm their personal condition and the society that surrounds them.

In line with a Problematization approach, the first and second questions were asked to provoke the researchers about what each brings from the various teaching methods, attempting to verify the basic and traditional concepts of average speed and rate. In general, most recognize the traditional concepts. Furthermore, they served as a basis to answer the final question, which questions the relationship between these concepts and the impact of the pandemic on the world.

We noticed some discomfort in the responses, which indicates teaching tied to the relation to motion. What is traditionally presented superficially and without a specific focus, the study of average school progression can be better approached through the Three Pedagogical Moments. The index is a topic worked on only through the mechanization of mathematical procedures; the dynamics of Problematization in the literature offers a better understanding of everyday life and a re-signification of why calculations are performed.

For future students this would represent a class with a more dynamic and dialogic approach. In the knowledge-organization stage, the systematization of the content on average school progression involves performing the relevant calculations and also enables a reflective discussion about the Problematization addressed. It is a moment when individuals develop their ideas and conceptions. Dialogue and Problematization provide a critical reflection on topics that relate knowledge of average school progression to various issues such as disease spread and mortality.

With the Problematization methodology, we intend to give formal Physics Teaching a certain level of commitment when addressing questions and themes as important as the relationships between Science Technology Society, which need to be treated systematically during basic education. This approach, through topics that have the potential to be meaningful for students, makes it possible, initially, to explore the second dimension of content through Problematization, with the first dimension, the traditional content itself, following as a consequence.

A teaching approach with more Problematization could help prevent, as seen in the current Brazilian scenario and discussed here, the lack of information tied to scientific illiteracy, which leads to mistaken interpretations of published data, opening space for charlatanism and anti-scientific attitudes, and resulting in ill-founded comparisons, such as people claiming that dengue kills more than Covid-19. In this type of comparison it is noticeable that the person making it does not perform a faithful comparison of the numbers of infections and deaths for the two diseases when related to the same time interval.

The whole set of data shows that the pandemic, at least when related to the concept of average rate of spread, is more interdisciplinary and goes beyond the limits of a single concept, which was not demanded until the arrival of the virus. But a process of scientific training and scientific literacy compatible with a high school context that can go beyond an exclusionary form of education is still needed. Therefore, beyond being a worldwide moment of the Covid-19 pandemic, it may take another 40 years.

Acknowledgment

We thank everyone who agreed to participate in research on Physics concepts amid a pandemic like none previously experienced. Most participants are affiliated with the Federal Institute of Rio de Janeiro (IFRJ), so we especially thank the students, former students, and staff of the Niterói and Duque de Caxias campuses.

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RESUMO
O ambiente escolar vivenciou grandes mudanças depois do início da pandemia em que, apesar da informação instantânea presente no mundo globalizado, a ignorância em relação ao coronavírus ainda levou a discursos falaciosos. Assim, queremos elucidar indícios de como um ensino tradicional de um conceito simples e frequente nas aulas de Física, de velocidade média, pode dificultar o esclarecimento quanto a condutas de proteção do contágio. Através da referência à abordagem metodológica da Problematização, se analisou de forma quantitativa e qualitativa uma amostra pública da população do estado do Rio de Janeiro. Os resultados revelam a urgência, no Ensino Médio atual, de um Ensino de Física mais direcionado para o entendimento dos conceitos.

PALAVRAS-CHAVES: Taxa; velocidade de contágio; velocidade de mortes; Ensino Médio.

RESUMEN
El entorno escolar experimentó grandes cambios tras el inicio de la pandemia en la que, a pesar de la información instantánea presente en el mundo globalizado, la ignorancia respecto al coronavirus aún condujo a discursos falaces. Así, buscamos dilucidar indicios de cómo la enseñanza tradicional de un concepto simple y frecuente en las clases de Física, el de velocidad media, puede dificultar la aclaración sobre las conductas de protección frente al contagio. A través de la referencia al enfoque metodológico de la Problematización, se analizó de forma cuantitativa y cualitativa una muestra pública de la población del estado de Río de Janeiro. Los resultados revelan la urgencia, en la Educación Media actual, de una enseñanza de la Física más orientada a la comprensión de los conceptos.

PALABRAS CLAVE: Tasa; velocidad de contagio; velocidad de muertes; Educación Media.