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Impact of Knowledge of Natural Sciences on ENEM Performance: Considerations about Scientific and Technological Inequality to Social Justice

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Keywords
Inequality; National High School Exam; Sociology of Education; Natural Sciences.

Abstract This paper sets out from the perspective sociology of education and sociology of science, aiming: analyze the performance of students in nature sciences compared to other areas of knowledge in the National High School Exam; analyze the performance of candidates from public schools and private schools; present preliminary considerations that indicate how the presence of scientific laboratories in schools show some evidence of improvement in performance. The debate goes through by mobilizing the concept of scientific inequality and cultural goodwill to propose an interpretation of data that allows a comparison between the performance in natural sciences of students from several school systems by comparative analysis among public and private schools. The data selection it reports on the microdata of the National High School Exam (ENEM) — 2017 edition — which was investigated the results of students from the final year (senior year) who scores between 600 and 1000 points in natural sciences in order to compare these results with other areas of knowledge. The data show that students from public schools have proportionally more significant performance (between fields of knowledge) in hard sciences (and writing) than students from private schools. In addition, it is found in this range of score of the analysis a disproportion of representativeness of students from public schools on objection of private ones that can be interpreted as a marked characteristic of social and educational inequality in the country.

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Introduction

The problem of social inequality has marked the work of researchers in different subfields of education (Peregrino, 2010; Peugny, 2014). The educational analysis that starts from this perspective aims, among different categories of analysis, such as economic, ethnic and gender differences, to indicate to what extent the social and cultural distinctions brought by students to the classroom can impact on learning and interactions with other actors as teachers, coordinators and the school community (Setton, 2011). While such research deals with these aspects, they enable debates beyond learning in the classroom and allow to cover such discussions about the future of young students and how their professional choices are not exclusively due to personal desire, but can also be associated what is known in the literature as "choice related to destiny" (Rocha & Perosa, 2008). This perspective is strongly influenced, albeit not only, by what Bourdieu and Passeron (2013) already pointed out about the destiny socially reserved for certain social groups.

In the Brazilian case, the complexity of the problem is due to the territorial dimension and the social and cultural distinctions that are inevitable within a country with continental geography (Gramani, 2017). To get an overview of what Gramani says (2017) it can mobilize data from 2015 National Survey by Household Sample (PNAD/IBGE, 2015), which indicated that the population of young people between 15 and 17 years "was 10.637.610; and the schooling rate was 85%. Among these young people, 1.593.141 were out of school; 1.863.158 were still in elementary school and 83.633 are illiterate" (Krawczyk & Silva, 2017, p. 14). By focusing on Secondary Education, in 2016, the enrollment rate for this phase of education in relation to Brazilian Basic Education as a whole was 16.7%, with 8.133.040 students enrolled in 28.400 schools. (Krawczyk & Silva, 2017).

In a comparative, exclusively quantitative, with Finland and their education system (Bastos, 2017), there are 93% of students who complete secondary education in comparison to the 5.5 million inhabitants in 2017 in that country, while Brazil, with 209.3 million inhabitants in the same year, had a dropout rate of around 6%, that is, of the students who enter high school, 94% have completed it (Abrinq, 2017). Although this data may seem encouraging, it is necessary to indicate that there are many young people between 15 and 17 years out of school. It means that only 68% of this population entered high school (IBGE, 2017). This debate, in general terms, already presents a difference in the national scale that makes Brazilian scientific education a relatively complex and distinct area from other countries[1] (Marguti et al., 2017). Still,

> "Despite the improvement in the indicators of access and permanence in school in the last 20 years in the country, the guarantee of the right to secondary education remains an unresolved issue by educational public policies, and the challenge of its universalization, with social quality, persists" (Krawczyk, & Silva, 2017, p. 14).

1 In terms of population, Finland has 2.6% of the residents of Brazil (Marguti et al., 2017).

If, however, faced with the challenges imposed, students in public schools begin the process of entering higher education, the choice made by the professional career or the academic future is not always straightforward. Studies show that this choice permeates different social and cultural experiences that permeate the dimension of a possible "personal choice" (Duru-Bellat & Van Zanten, 2009; Rocha & Perosa, 2008). When choosing an undergraduate course in higher education, high school students mobilize issues such as the social status of the profession or there are cases in which, by implicit routes associated with symbolic violence, they lead to situations that direct such choice by pragmatic criteria, where it is observed that *"socially disadvantaged groups could be being diverted to peripheral higher education, thus reinforcing the sector's stratification and social differentiation*" (Morley, 2013, p. 424).

In economic terms, Pires (2015) points out that students from families with an income above twenty minimum wages have better performance in large-scale assessments such as National High School Exam (ENEM), having even greater influence in terms of correlation to the educational formation of the father figure. Such debates advance through studies of these kind of evaluations, where inequalities are shown to be a historical factor that have been impacting the entry into higher education of representatives of disadvantaged socioeconomic strata. (Silva et al., 2011; Costa-Beber et al., 2014).

Some authors (Archer et al., 2015) some authors argue that scientific learning also has a social aspect and contribute to this process of social exclusion. Their studies have shown that the existence of capital, similar to a cultural capital (Bourdieu, & Passeron, 2013), associated with science, has become prominent in English students who aspire to scientific careers or studies aimed at the hard sciences. In Brazil, some studies have mobilized this discussion, which social elements influence the formation and professional choice of candidates and participants of the Brazilian university universe. (Kleinke, 2017; Nascimento et al., 2019; Lima Junior et al., 2013; Silva, & Barbosa; 2019). However, a question remains unanswered in such a debate: How do natural sciences, as school knowledge, influence (or do not) the entry of students in Brazilian higher education?

Faced with the challenge of answering part of this complex question, this research intends to analyze the impact of scientific knowledge, compared to other areas of knowledge of the National High School Exam, in the final grade of the students who participated in the two days of tests of the 2017 ENEM edition and also obtained results above the 600[2] points in Natural Sciences[3]. This assessment has a fundamental role in accessing higher education, while the analysis aims to understand the conceptual and procedural level of natural sciences by students. Therefore, the objectives of this study are: (1) Analyze the performance of students in nature sciences compared to other areas

2 Students who achieve this score have a reasonable chance of competing for places in public higher education, therefore, being a base score for recognizing that such students were successful in ENEM.

3 In this article, the term "natural sciences" was used to refer to the knowledge of the physical, chemical and biological sciences whereas "Natural Sciences" to represent the area of knowledge of ENEM.

of knowledge at ENEM; (2) Analyze, in order to counterargue the score, the performance between students from public and private schools; and (3) To present preliminary considerations of the results that indicate how the presence of scientific laboratories in schools can give signs of improvement in the performance of the students.

It will be sought for to discuss the extent to which scientific knowledge plays an important role in the formation of high school students from public schools, as well as, how many of these students perform in the high scores of ENEM compared to private school students. The aim of this debate is to defend the teaching of natural sciences in the classrooms as a determining factor to trace the historical and future trajectories of the economically and culturally less privileged students.

Scientific-Technological Inequality

To think about social and educational inequalities, it can turn to economic views that play a crucial role in the ways in which the cultural practices of the last 40 years in Brazil behave. Libâneo (2012) argues that the imported view of the motto "education for all" is rooted in documents and speeches sponsored by the World Bank in the 90s, whose vision of a solidarity school to the poorest has gained perverse outlines of an education that is less and less committed to the teaching of science and culture as a condition for develop a cognitive critical, affective and moral of these students. This "neoliberal invasion" in our (globalized) society has generated a new perception, too, of what it would be known about science. This understanding was marked by the consumption of products generated in different countries, in different (de) humanized situations and in different economic conditions. Thus, the knowledge of the processes ended up being left aside in opposition to the acquisition of material goods and less to cultural goods (Cunningham, 2002).

Such pragmatic relations with knowledge, based on the consumption of objects in an uncritical way, usually avoid the mobilization of analytical reflections on technological apparatus and the non-neutrality of science (Delizoicov & Auler, 2011). Science becomes a mere "mediating" instrument between need and well-being, without any connection with the dimension of access to its production. The "loss of the sense of science", as a symbolic asset, generates the "loss of the sense of scientific learning" in the students' school life. In the long run, this apathy towards the natural sciences leads to departures from the knowledge of everyday life.

For a better understanding of these dimensions, it is necessary to mobilize two theoretical frameworks. Pierre Bourdieu (1994) which recognizes that symbolic goods have a fundamental role in social distinctions and, complementarily, Charles Tilly (2006) which advocates that science has become, in addition to a cultural acquisition, one of the most important assets to define social inequalities, coining it under the term "scientific-technological inequality". To understand how science has become a "symbolic good" (Bourdieu, 1994) which, subsequently, was characterized as one of the pillars of social inequality, it is relevant to understand the boundaries of this reflection that will allow the debate of data.

Science, according to Bourdieu (2001), is divided between pure knowledge and political game. In this context, in the scientific field (space of battles), the knowledge of natural science has an important role as an element that defines the basic rules of the game in this social space (Bourdieu, 2001; Sapiro, 2004). The battle for scientific authority is based on two central logics, opposing in the field, and which are derived, in part, from the institutional (political and temporal) and pure (prestige) scientific capitals (Montagner & Montagner, 2011).

In other words, to be accepted in this field it is necessary to have something valuable, that is, the symbolic instrument valued by scientists and recognized among their peers: scientific knowledge (Bourdieu, 2003; Gurgel & Watanabe, 2020). Such perspective, it is worth pointing out, is based on the processes of knowledge production and involves debates on the development of natural science thinking. Part of this discussion is the result of the macro-social (economic) dimension that leads to the dimension of the relationships established in the process of developing this knowledge and is related to the interactions between the political and scientific fields. Such representation gives scientists different types of capital that evoke both the dimension of investment in intellectual recognition in the field (pure scientific capital) and the dimension of institutional policies (political scientific capital) (Bourdieu, 2004). When pure scientific capital is observed, such knowledge, due to its dimension of difficult access, makes this field almost impenetrable for those who are not part of this social space, as well as making it very difficult for other social actors to insert themselves in this environment under the point of view of the development of scientific knowledge. Therefore, there are few social agents that can act in this field, giving opinions or indicating ways of how science should develop, that is, recognizing it as an autonomous field (Bourdieu, 2001).

This autonomy of the field (Bourdieu, 2004) is configured as a characteristic of the social space of science, constituted by its historicity, attributing a type of social artifact that guarantees its legitimacy and its safeguard in the face of the distinct political and economic interests that permeate the work of scientists and society's demands (Bourdieu, 2003).

However, it is questioned, if it can be said that the natural sciences are knowledges directly superior in the hierarchy of academic thought and of society in general, because the access to information and the current need for dialogue between university and society does not promote greater and better rapprochement between science and the general public. While the science produced by scientists who participate in a social game that involves different kind of disputes for the maintenance or changes in positions and power relations, the selection of curricular knowledge in science education, even in another social space, also constitutes its own knowledge, committed to the school space, which permeates their battles and specific interests.

To try to understand this reflection, it will mobilize the idea of "cultural arbitrary" (Bourdieu & Wacquant, 1992) as a theoretical instrument that can support the reflection on the relationship between knowledge of the natural sciences and teaching. When approaching the idea of culture as an anthropological conception, the author does not objectively define superiority to the different ways of representing the world (Bourdieu, 2011), in other words, "*the values that would guide each social group in their attitudes and behavior would, by definition, be arbitrary, they would not be based on any objective, universal reason*" (Nogueira & Nogueira, 2002, p. 28). Thus, the "cultural arbitrary", which can be approached here in science education, would not have any kind of logic or justification that would lead it to a type of language that would have more legitimacy than another language to be taught[4]. A possible defense is in the understanding that the natural sciences as school knowledge is rooted in common cultural goods (Forquin, 1993) produced by humanity, being permeated by its relevance as a historical construction and based on rationality. However, according to Bourdieu and Passeron (2014) "all teaching, and more particularly the teaching of culture (even scientific ones), implicitly presupposes a body of knowledge, know-how and, above all, know-how, which constitutes the heritage of the educated classes" (Bourdieu & Passeron, 2014, p. 39).

In the face of such a debate, the question that arises is whether the transposition of scientific knowledge as a symbolic asset in the scientific field, when re-elaborating itself as a cultural arbitrary in the school space, could not be understood as knowledge with practices and knowledge that come from the same epistemological structure, but with a distinct social nature. Such questioning aims to understand whether the idea of a symbolic good with value within the social field of science can also be a symbolic good with social value outside that field.

This reflection leads us to defend that the acquisition of scientific knowledge in the educational field would provide a role as relevant to social justice as holding this symbolic asset for the scientific-technological inequality proposed by Tilly (2006). Based on this assumption, it is understood that Tilly (2006), by mobilizing the theme of scientific-technological inequality in his work, has as an important reflective instrument the understanding of know as that associated with the knowledge of the scientist. For this author, the definition of what is currently understood by distinctions in an increasingly technological and virtual world it is associated with the symbolic power connected to the knowledge of the sciences. Science and technology — and their development — are important to define what a politically powerful, developed or potential nation would be (Tilly, 2006). Examples such as uranium enrichment bring significant terms to political decisions on the table, as well as the role that scientific and technological knowledge plays in building alliances and mutual respect between dominant countries in economic policies (Neves, 2015).

As Tilly (2006) pointed out, the knowledge of science and technology has today become significant political instruments to define inequalities, whereas in the school environment, mobilizing a Bourdieusian perspective, it is almost absence can evoke an

4 Certain caution is necessary in this debate, since scientific knowledge is a knowledge instituted in the field by the rationality of its thinking, therefore, its relevance passes through the scrutiny of scientists. In the case of the "cultural arbitrary", what is discussed is how the ways in which science is presented can lead to a type of cultural privilege that some students do not have, such as their language, for example.

increase in the distinctions that are perpetuated throughout the students' lives, assigning to each of them a future reserved for their social and cultural class. Thus, scientific-technological inequality, even for Tilly (2006) is within the scope of geopolitical decisions and consequent macro-social perspectives, can be thought of in the space of microsocial practices when observing the role of natural sciences in the school context as cultural arbitrary as Bourdieu and Passeron (2013) once had pointed.

An example of such differences occurs in the scientific language that is communicated at school through technical terms and that can be understood as the core of symbolic violence (Bourdieu, 1994). This is because language is represented in the way the discourse is delivered, since its academic bias associated with elite speech is the barrier stipulated by domination to understand science and not necessarily the technical vocabularies (Archer et al., 2015).

In this sense, the cultural capital (of the elites) is already established in the students' ways of being (habitus) and institutionalized in the school capital of the privileged classes (Claussen & Osborne, 2012). On the other hand, in the scientific field, language is a basic factor of entry into the field, that is, a candidate in the field by ignoring mathematical elements or technical terms it will be very difficult for him to act as a scientist in the field of science, for example (Gurgel & Watanabe, 2020). In short, the educational space, as this regulatory environment for the distribution of cultural capital, may have found in the 21st century, in the knowledge of the natural sciences, the cultural and symbolic capital that needs to be measured within the fractions of classes from which it must be taught and learned (Silva & Wright, 2008).

The biographical crises in the educational theme raise reflections on how students make trajectories different from those expected due to their social origins and, although they are not the majority, they are important sources of analysis. However, it is worth thinking which paths should be taken so that the different trajectories become routine trajectories, which leads the present work to initiate some questions about macrosocial elements that seek to understand the mass of students outside higher education and those who enter it, acting on the margins of public education, they focus their efforts on the private university system, sometimes with lesser social and academic prestige. Again, the role of scientific knowledge as a political instrument in contributing to social and educational inequalities and justice is questioned.

Methodology

The social sciences adopt statistics as an instrument not only for diagnosis, but also for the verification of several aspects of reality, enabling the delimitations and analyzes of social spaces. The search for a methodology that can incorporate critical research, within the scope of statistical data, has indicated a tension in the field of educational research. Seen under the limitations of such mathematical methods, it has been pointed out to what extent working solely with quantitative data can bring insights capable of understanding complex problems such as those of education (Ferrare, 2011).

Among the different spectra of the nature of such criticisms, associated with the critical methods of thought, it is worth emphasizing the problem of causality. For Ferrare (2011) when statisticians seek to understand a fixed attribute from different associations with other fixed attributes, they end up promoting direct relationships, whereas, for critical educators, such relationships are more complex, associated with actors and objects in processes fickle in historical time.

> Explaining social phenomena is understood as a process of understanding the social context (relationships) in which the actors are inserted. The way in which causal/experimental education researchers deal with the idea of context is decidedly different from critical education researchers. The former is interested in the context as it prepares them to add precision to their explanation of fixed attributes (Ferrare, 2011, pp. 513–514).

The very choice of microdata for a large-scale evaluation brings challenges and reflections on the problem raised in this article. If the criticism of the neoliberal context in education has created distortions about the meaning of the school, it is understood that such tests are attempts to transform learning into a quantitative indicator without commitment to the effective right to education of young Brazilians (Libâneo, 2012). Therefore, it would be prudent to assume that microdata can lead researchers to misinterpretations of educational quality and find, at its core, an uncritical bias of "*education for capitalist restructuring*" (Libâneo, 2012, p. 20).

To avoid such a trap, it is understood that the determining factor to understand the role of statistics in this research is that, some researchers work with inequality in education as a variation of performance, reducing interpretation of the subject's location in the distribution of an assessment standardized as ENEM. In this research, statistics play a different role because it indicates, in terms of Bourdieusian studies, whether the questioning produced in the hypothesis leads to a real[5] problem or closest to the real. It is intended to understand whether the idea that scientific knowledge has a significant or innocuous role for social inequality is a plausible question to be addressed or just an academic view instituted by the set of theoretical problems raised along the trajectory of the researchers. It is understood that such a perspective can avoid a *"theoretical reduction (which) completely ignores the forms of curricular inequality (...), linguistic (...), cultural capital* that may be associated with the worked data*"* (Ferrare, 2011, p. 515).

Faced with this challenge, the data provided by the Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira — INEP (National Institute of Educational Studies and Research Anísio Teixeira). The Institute annually discloses the microdata about ENEM, being this kind of data the lowest level of aggregation of collected by the surveys, evaluations and examinations carried out. These are open access data and can be obtained online by accessing the digital platform[6]. The analysis presented here refers to the microdata of the 2017 ENEM edition.

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5 Truth in Bourdieu's theory refers to the proximity with the sense of the real according to the social dimension reflected in the practices of social agents.

6 http://inep.gov.br/web/guest/enem.

With the results obtained, an analysis based on the assumptions from the perspective of scientific-technological inequality was used as a source of interpretation. For the realization of the empirical study, the exclusion criteria were students who participated in the Natural Sciences and its Technologies test, but did not participate in the second day of the test, that is, they were present in one day, but not in the other day. Also, only those who declared themselves enrolled in the third year of high school and who would complete it in 2017 in a Brazilian school were investigated (n = 1.384.929)[7]. Therefore, students who are not enrolled in a basic education school, have already completed or will finish (trainees) but made the assessment — and were present in the two test days — are an expressive number (n = 3.041.167) and needed to be removed from the analysis data for the purpose of profiling the research corpus[8]. All data were treated with the statistical software Alteryx Designer 2019.4.

The performance tables are separated according to the area of knowledge and organized according to the number of participants by proficiency range. Our efforts were concentrated on organizing and systematizing the results so that they would be readable and understandable. In this sense, for each area of knowledge, the results were represented in tables and dispersion graphs.

Concomitantly, there was an investigation related to school infrastructure information with the ENEM microdata. This perspective was possible by the manipulation and intersection of the microdata from the 2017 School Census, also made available by INEP[9], with the ENEM microdata, from the candidate's school code. In this way, the data related to the existence (or not) of science teaching laboratories in schools was obtained, crossing them with the performance of the candidates. Such data shows another perspective of analysis in order to contribute to the promotion of critical and sociological reflections, which are incorporated in this study.

Results and Discussion

Before starting the analysis and discussion of the data, it is important to note that in an overview of the results (with total data) it can be seen that 1% of students perform at the extremes of what would be a Gaussian curve with very low or high marks. t is recognized that such distribution is associated with the functioning of ENEM, since the test adopts the Item Response Theory Model (TRI) and not the Classic Test Theory (TCT). While the TCT expresses the gross or standardized values, the TRI proposes models that analyze characteristics of indirect analysis (Ferreira, 2018). This implies that the ENEM score is not only calculated according to the number of correct answers, but also considers the coherence of these answers, that is, the ENEM questions are classified in levels of difficulty according to the proportion of subjects who settle more or less

7 Candidates present at the two test days and who declared that they were attending high school and would finish it in 2017 were 1.385.588. However, 653 were from a foreign school and 6 had no information on the type of school management. Thus, resulting in a population capable of analyzing of 1.384.929.

8 Candidates excluded from the analysis, even being present in the two test days, who declared themselves: 1. Concluded the HS (n = 2.529.430); 2. Enrolled in the HS and do not conclued in 2017 (trainee) (n = 481.766) e 3. Do not concluded or do not enrolled in HS (n = 29.971), sum of total 3.041.167.

9 The 2017 School Census, made by INEP can be accessed at em: http://inep.gov.br/microdados.

certain questions - the more correct answers a given to the question, more it considered as easy, while questions with a low hit rate are considered more difficult. The subject's final grade will take into account not only the questions he got right, but which ones he got wrong and the level of difficulty that question had in that sample group. Therefore, this score is calculated taking into account the number of correct answers and the coherence of the participant's responses.

This consideration is relevant, since the data presented here are the result of students' performance compared to the general performance, comparatively, of the other candidates. In other words, it is conceived that so few students obtain grades above 800 points and below 300 points, it is not only related to the successes and errors, since there may be students who answered almost all questions correctly and, still, did not reach values close to a thousand points, and students who missed almost all questions did not have values close to zero points.

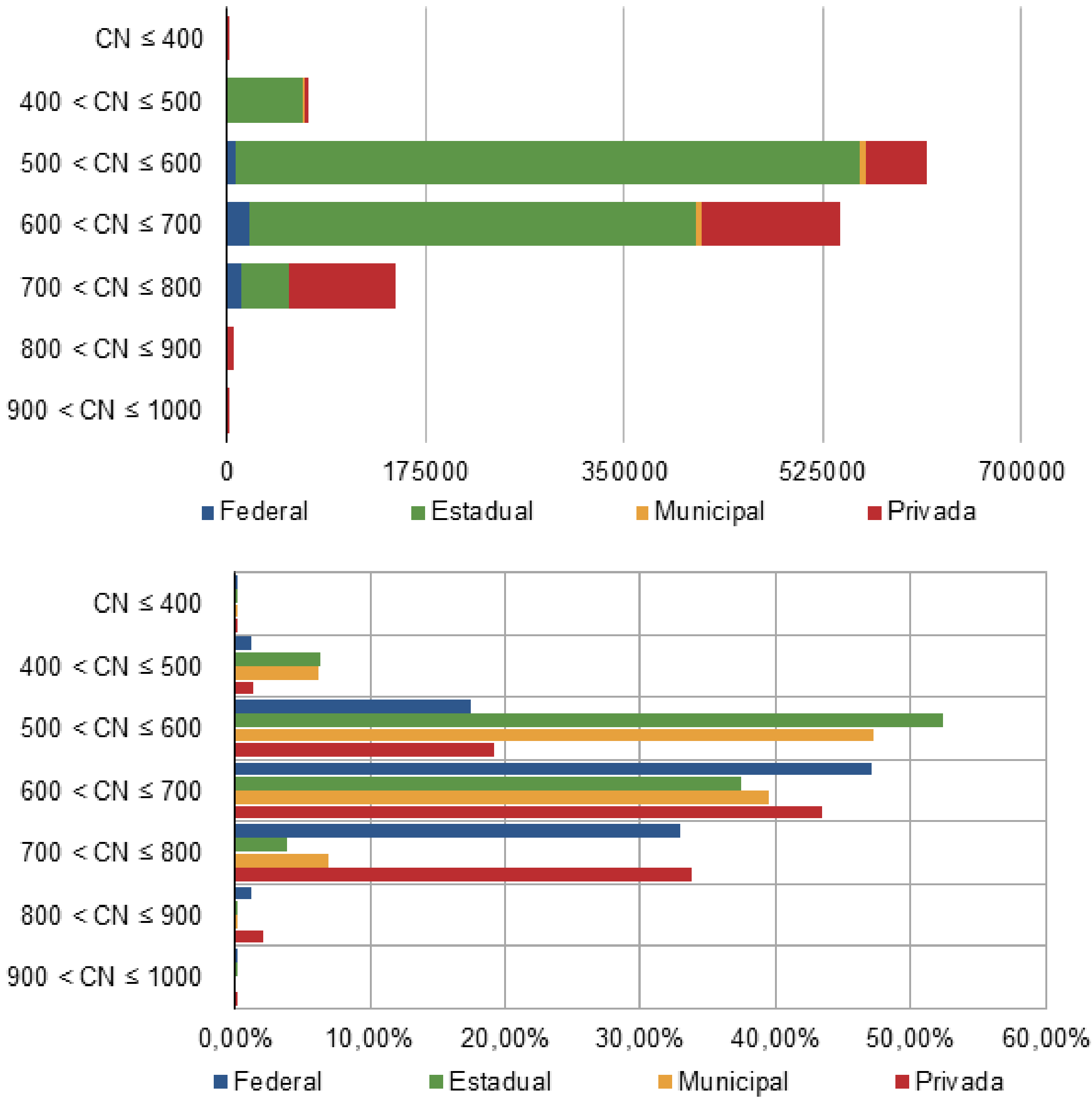
For the analysis of microdata, it was decided to treat the results of students from public (state, federal or municipal) and private schools, in the score of students with a range of "correct answers" above 600 points in Natural Sciences. As previously discussed, the symbolic asset "scientific knowledge" (Bourdieu, 2004) has been shown, according to Tilly (2006), as a determinant knowledge for social inequality. It is important to understand the extent to which students who have high performance in this area of knowledge, can be represented according to their training at the school of origin. Since education is one of the most striking factors of social inequality in the country, it can be recognized that access to science knowledge would prove to be a dimension (among many) of this unequal distribution of cultural capital (Peregrino, 2010; Silva & Wright, 2008).

In order to analyze the range in Natural Sciences above 600 points, the focus was on detailing the performance ratio of students in these schools in order to subsequently treat the microdata to compare their results. It is worth pointing out that at some times public schools are included in state, municipal and federal, but adding that they do not significantly influence the data by the volume of students at the state school. However, ahead, these data will be presented separately for the purpose of detailing the debate.

The results shown in Figure 1 are presented in absolute numbers and percentages, in relation to the distribution of the grades of sciences in Natural Sciences. We see in the data, as already pointed out by Silva and Ney (2011), that while the bulk of students in public schools are being left behind in terms of representativeness, students in private schools begin their journey towards "school success" with marked indications of school performance distributions.

The percentage representation was performed, since the number of students from public schools is, in absolute numbers, much higher than students from private schools, making it impossible to represent a comparative graph (Figure 1).

Figure 1. *Distribution of candidates for frequency of points in natural sciences in absolute numbers and percentages*



Source: the authors.

When observing the percentage distributions of students by range, as shown in Figure 1, it can be seen that the distance of students from state and private schools drops dramatically in the 600-700 range, and inverts into total representation in 600 points. It is noted that students from federal schools have similar performance, however, they are in absolute numbers much smaller than those from private schools, which is in dialogue with works close to those presented here (Nascimento et al., 2019).

If during the distribution of grades there are always more students from state schools than private ones being represented up to the range 500–600 points, which can be considered normal, since there are numerically more students in public schools than private ones, when grades in science the range of 600–700 points, it is observed that this distribution is inverted. In particular, we can see an uneven distribution when we look at students who manage to score in the upper 900-point range onwards. It is noteworthy that, in this case, the representatives of the private schools are 55 students, while, in the state school there is 1 representative who manages to reach the peak of the grade in the tests of Natural Sciences in ENEM of the year 2017.

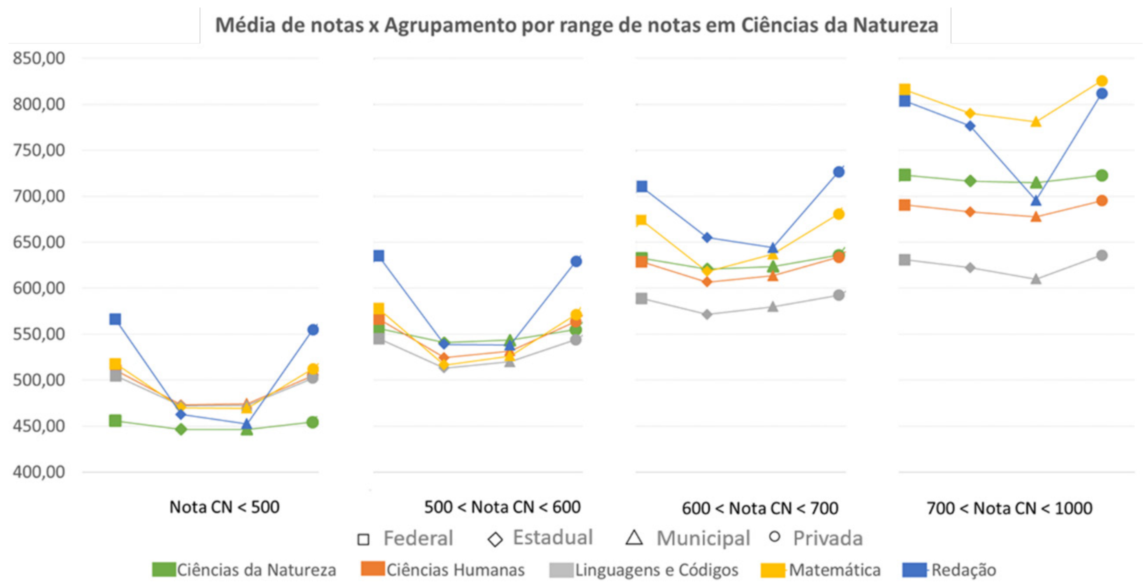
This discrepancy becomes more explicit when it is taken into account the total number of students, in absolute numbers, in the Natural Sciences test is compared by administrative sphere: in the state sphere there are 1.050.516 students, while in the private sphere there are 278.747 students. Therefore, analyzing proportionally the totals from each sphere it is found that 79.34% of all students (n = 221.182) from the private schools have reached 600 points while 41.32% (n = 434.177) of the students from state schools scored in the same range. Such results are yet general but they indicate that there are discrepancies between students from public and private schools with regard to knowledge of the Natural Sciences. This global dimension of ENEM data cannot be recognized as an initially striking factor for understanding the impact of natural sciences on educational and social inequality. (Kleinke, 2017). It is intended to look in more detail the distribution of grades of public and private schools regarding to scientific knowledge in terms of comparison to other areas to support the proposed debate.

If for Tilly (2006) science and technology are shown as an apparatus of political power that influences different spheres of society, leaving in the 21st century a set of social actors on the periphery of the debate about these political decisions, perhaps there are indications of how such knowledge can impact students' performance, too for entry into higher education (or if it does not have any type of relationship compared to other areas of ENEM) (Helene, 2013).

In view of the above, it was decided to recognize how the grades of these young people with good performance in this area of knowledge are distributed in comparison to the other knowledge present in ENEM. This is because the importance of analyzing the extent to which students have links with cultural capital and their relationship with the natural sciences is understood (Claussen & Osborne, 2012). This relationship influenced by other areas of knowledge, which may present indications of their role in the educational formation of students in the face of the overall performance in the ENEM (Peugny, 2014; Pires, 2015; Silva et al., 2011).

To try to initiate this analysis, the graph in Figure 2 illustrates the behavior of the general averages for each axis of knowledge and the type of school of origin, grouping in ranges of grades in Natural Sciences of the candidates.

Figure 2. *Average grades in grouping by grade ranges in Natural Sciences*



Source: the authors.

For the reading of the graph in Figure 2, it can be seen that the grades below 500 and above 700 were grouped and presented in a single interval to facilitate the reading of the graph. The graph presented is intended to promote the comparison of performance between schools (in terms of their grades for each area. it can be seen that in green are all the notes referring to the Natural Sciences and, for the square symbol the representatives of the federal schools, followed by the diamond symbol for the state group and so on. This logic is repeated for each range of grades obtained.

It appears that the candidates who obtained a score lower than 500 in Natural Sciences, were also the ones who presented the lowest averages in Natural Sciences compared to other areas of knowledge, which does not occur in all other ranges of points, regardless of the type of school. This factor seems to play an important role and deserves more detailed studies. However, it is worth pointing out that the low performance of these students of the Natural Sciences can give evidence of the question pointed out by Tilly (2006) about how scientific-technological knowledge has a facet that needs to be better explained as, in the case studied, it reflects the worst performance in this area compared to all others for students with scores below 500 points. In this case, as pointed out by Claussen and Osborne (2012) and Archer et al. (2015), the sciences and their social role, linked to the school space, need to be discussed in view of the different inequalities they generate in the training of students.

Towards higher scores, there is a preponderance of writing and mathematics averages. Those related to Languages and Human Sciences, on the other hand, remain as those of lower averages, while those related to Natural Sciences have risen, matching them in the range of “500 <Note CN <600” and overlapping in “700 <Grade CN <1000”, regardless of the student school background. Attention is drawn to schools in the federal sphere (Federal Institutes of Education, Science and Technology) that follows the performance of private schools. Such a debate, as already pointed out by Nascimento (2019), indicates different factors, such as the career of teachers in the federal teaching profession and the selection tests of these institutions that constitute a social and cultural bottleneck for students at federal institutes, the result of a "superselection" "of these students (Bourdieu, 1964). It is observed, therefore, that the notes of Sciences of Nature gain, in general comparative terms to other areas, a prominent role for students who have access to this knowledge in grades above 600 points in opposition to the Humanities and Language. This result can be understood as an interesting inversion and, consequently, the impact of this knowledge, whereas the student seems to obtain better success in the evaluation of ENEM when the Natural Sciences become more relevant compared to the other two areas. This aspect shows, even though initially, that there is a certain approximation with the debate that the natural sciences reveal themselves as a possible knowledge for social justice, when realizing that from the range of 700 points onwards the student from state school has significant performance compared to other intervals (Libâneo, 2012; Krawczyk & Silva, 2017).

However, the results above show little about how the natural sciences can impact the performance of students in public and private schools. To bring a more detailed analysis, it is understood that it is necessary to observe the profile of the successes and errors of the other areas of knowledge and how they are behaving in relation to the Sciences of Nature. For that, we can observe that, as already found in other works (Nascimento, 2019), the profile of federal public schools such as the Institutes of Education, Science and Technology (IFs) and private ones have similarities (Kleinke, 2017; Nascimento et al., 2019). It is likely that students from the federal schools are similar to those from the private ones because they are the result of a superselection process (Nogueira & Nogueira, 2002) that is, these subjects, throughout their trajectory, would have survived several selections based mainly on their cultural capital (Bourdieu & Passeron, 2013; Peugny, 2014; Setton, 2011; Silva et al., 2011).

In order to seek some interpretations for such demands, analyzes composed of two scatter plots were elaborated[10]; a normal distribution graph; and a table with the percentage distribution. For this analysis, as previously mentioned, only students who obtained a score greater than or equal to 600 points in Natural Sciences were considered.

Regarding the *scatter plots*, located at the top of figures 3, 4, 5 and 6, the scoring in Natural Sciences is on the horizontal axis and on the vertical axis the comparison of the candidate's own scores for a given area of the knowledge with that of Natural Sciences. For example: a student who obtained 600 points in Natural Sciences and 700 points in Human Sciences, when comparing his Human Sciences scores with that of Natural Sciences we would have 1.1666 (700/600 = 1.1666), that is, the student obtained a score about 16.66% higher in his grade in Human Sciences compared to his grade in Natural

10 These two graphs need to be analyzed in an integrated manner, as a single resultIt was necessary to separate two graphs due to the difficulty of observing the data, since there is an expressive number of students from private schools that made it difficult to visualize the distribution in general.

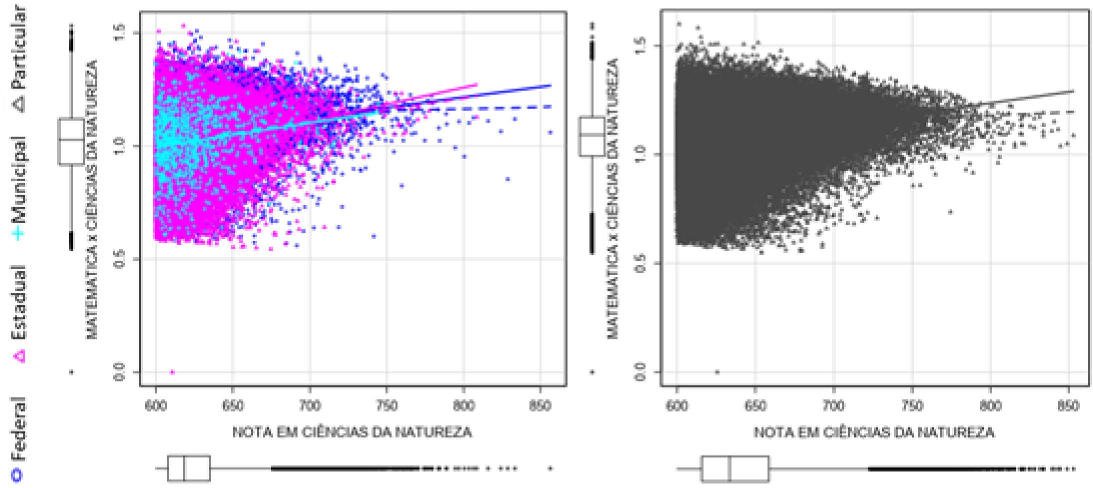
Sciences. In the graph, this student would be recorded as a point of intersection of the horizontal axis (600) with the vertical axis at (1.1666). In summary, for the vertical axis, we can interpret that students who are above the value 1, obtained a score of Sciences of Nature inferior compared to the other axis of knowledge; if equal to 1, the candidate scored the same in Natural Sciences and on another axis; if less than 1, the candidate obtained a higher score in Natural Sciences than that of another axis of knowledge.

The *graph of normal distribution* — at the bottom of figures 3, 4, 5 and 6 — we have on the horizontal axis the comparison of the score of Natural Sciences with that of a given axis of knowledge (analogous to the vertical axis of the dispersion graph), and on the vertical axis the probability density.

The table — located in the central part of figures 3, 4, 5 and 6 — shows the distribution (in percentage) of the candidates based on the comparison of scores of a given axis of knowledge and that of Natural Sciences, of the candidate himself. For such a distribution, we have three scenarios: less than one standard deviation; -1 standard deviation ≤ general mean ≤ +1 standard deviation; greater than one standard deviation. It is worth mentioning that, mathematically, the interval between "-1 standard deviation ≤ general average ≤ +1 standard deviation" would represent a concentration of 68.26% of the students who were present in the two test days, were in the third year of high school, and obtained a score equal to or greater than 600 points in Natural Sciences. Therefore, the objective of this table is to present how the candidates are distributed, based on the type of school of origin.

As shown in Figure 3, through a macrosocial analysis, a maximum variation of about 50% between the sciences of Nature and that of Mathematics is observed, that is, coming close to 1.5 (candidate obtained a score in Mathematics of almost 50% higher, if compared to his grade in Sciences of Nature) and 0.5 (he obtained a grade of Sciences of Nature of almost 50% higher compared to his grade in Mathematics). Towards increasing scores in Natural Sciences, however, there is a tendency to reduce this variation, and a slight rise to quadrants higher than 1.0, indicating that candidates performed slightly better in Mathematics than in Natural Sciences.

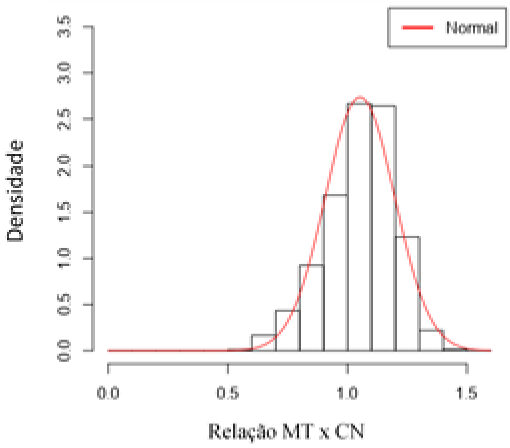
Figure 3. *Mathematical x Natural Sciences Relationship*



Matemática x Ciências da Natureza

Total candidatos	< 0,906903	0,906903 ≤ MT x CN ≤ 1,198355	> 1,198355	Escola origem
14312	13,81%	68,61%	17,57%	Federal
40410	26,51%	66,39%	7,10%	Estadual
977	19,65%	71,65%	8,70%	Municipal
100136	12,37%	69,68%	17,95%	Privada

Média: 1,052629
σ : 0,145726



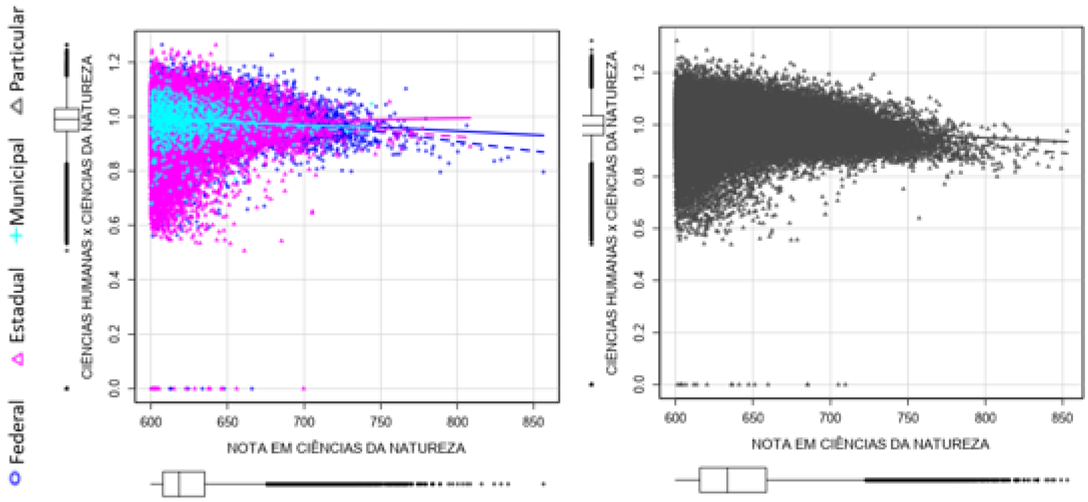
Source: the authors.

Another information to be highlighted is that, when we analyze these candidates with a score of 600 points or more in Natural Sciences, those from the State and Municipal spheres outperform — in percentage — the Private and Federal students in the range "<0.906903" (obtained the score in Sciences of Nature higher than that of Mathematics, by at least 10%) and are more distributed in this, than in "> 1.198355". Therefore, when analyzing the extremes, candidates from the State and Municipal networks tend to do better in Science than Mathematics.

Figure 4 shows the comparison of Human Sciences with Natural Sciences. According to the table, once again, when comparing the extreme intervals in percentage, the students in the State and Municipal spheres are more distributed to the interval in which the students obtained higher points in Natural Sciences than in Humanities.

Regarding the dispersion graph in Figure 4, a mild downward trend is observed for the quadrants below the value 1.0 as the grade in Natural Sciences increases. The general average of 0.9899, with a standard deviation of 0.0710, tells us that the comparison of the notes of Humanities and Nature Sciences are not as dispersed as those of Mathematics and Nature Sciences, which had a general average of 1.05526 and standard deviation of 0.1457.

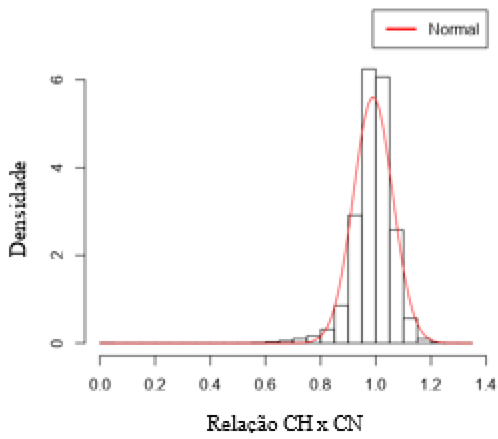
Figure 4. *Human Sciences x Natural Sciences Relationship*



Ciências Humanas x Ciências da Natureza

Total candidatos	< 0,918868	0,918868 ≤ CH x CN ≤ 1,060994	> 1,060994	Escola origem
14312	10,61%	76,10%	13,29%	Federal
40410	16,47%	73,64%	9,90%	Estadual
977	12,49%	77,89%	9,62%	Municipal
100136	9,30%	78,03%	12,67%	Privada

Média: 0,989931
σ : 0,071063

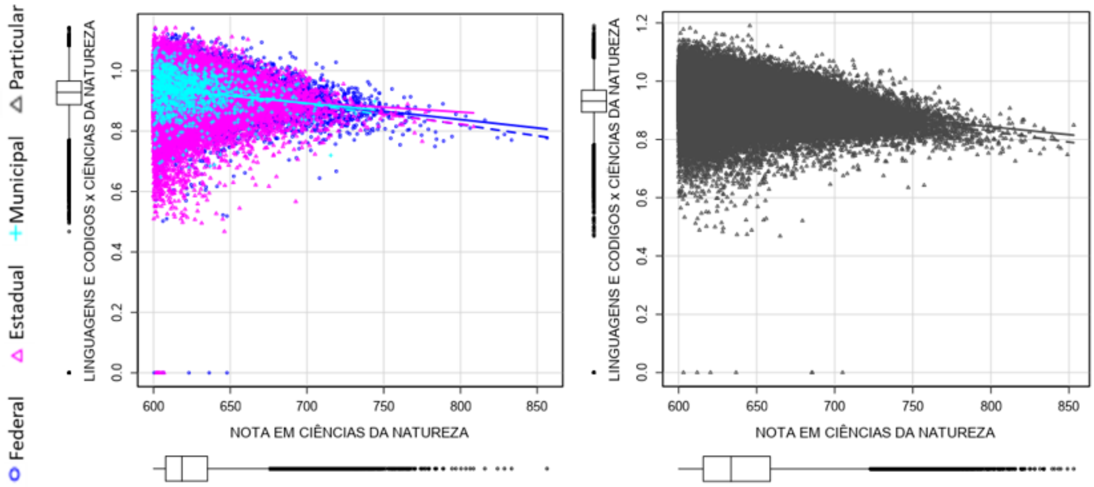


Source: the authors.

From Figure 5, which shows the dispersion graphs of Languages and Codes and Natural Sciences, it is also possible to infer, with even more emphasis, the descending characteristic for quadrants below 1. This means that most of the candidates analyzed in 2017 obtained a higher score in Natural Sciences when compared to their scores in Languages, so much so that the overall average of the comparison was 0.9270 with σ = 0.0628.

The percentage distribution table also indicates that a good part of the candidates is in quadrants less than 1, reinforcing that the majority of the candidates had a higher score in Natural Sciences than in Languages and Codes. Furthermore, when comparing the extremes, once again the candidates from the State network are more concentrated (in percentage) in the interval that indicates having obtained a higher grade in Natural Sciences than Languages. And this is no different when we compare Writing and Natural Sciences.

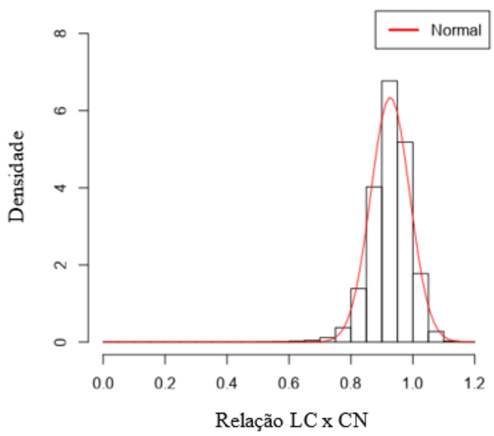
Figure 5. *Languages and Codes x Natural Sciences Relationship*



Linguagens e Códigos x Ciências da Natureza

Total candidatos	< 0,86416	0,86416 ≤ LC x CN ≤ 0,989864	> 0,989864	Escola origem
14312	12,30%	72,97%	14,72%	Federal
40410	16,90%	70,51%	12,58%	Estadual
977	12,49%	73,29%	14,23%	Municipal
100136	12,50%	72,97%	14,53%	Privada

Média: 0,927012
σ : 0,062852

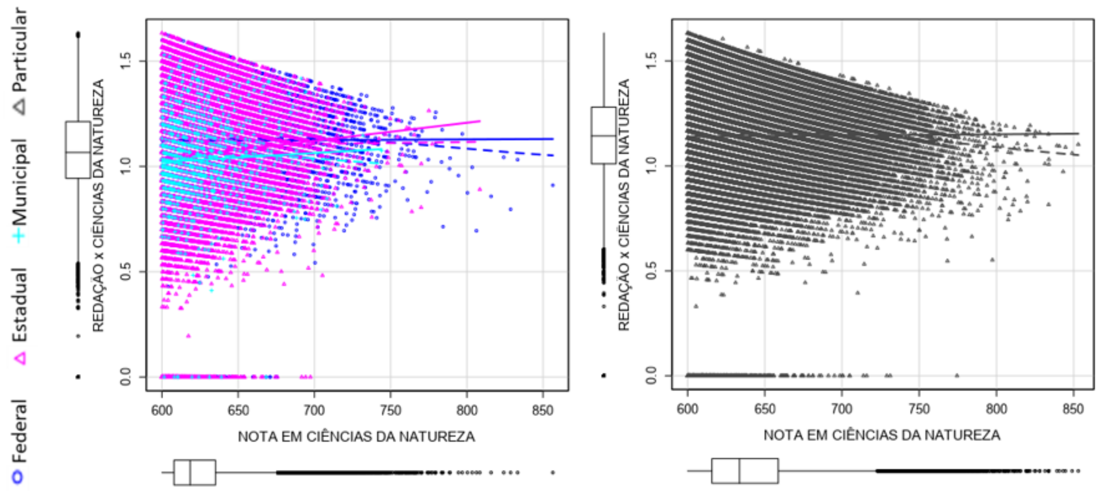


Source: the authors.

Figure 6 also indicates that there is a greater concentration of candidates from the state and municipal schools at "<0.910478", with 21.34% and 22.52%, respectively, while the private ones have 10.10% of its public in this interval and the federal with 11.84%. On the other hand, from the scatter plot, it is possible to infer that there is a variation in the scores of the same candidate when we compare his score in Natural Sciences and Writing.

As pointed out in the data, it can be learned that the Natural Sciences test is proving to be important in the training of public schools' students at ENEM. It is noteworthy the extent to which this distribution positively affects the final grade of students in public schools compared to the performance of students in private or federal schools. What these results seem to indicate is that there is a significant mass of students from state schools who have performance in natural sciences good enough that can support them to compete for highly selective courses.

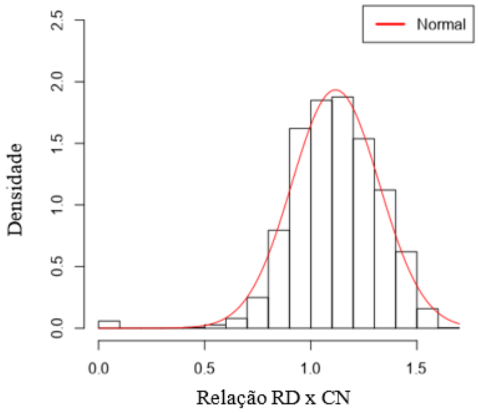
Figure 6. *Writing x Natural Sciences Relationship*



Redação x Ciências da Natureza

Total candidatos	< 0,910478	0,910478 ≤ Redação x CN ≤ 1,322916	> 1,322916	Escola origem
14312	11,84%	72,43%	15,73%	Federal
40410	21,34%	68,15%	10,51%	Estadual
977	22,52%	70,21%	7,27%	Municipal
100136	10,10%	71,28%	18,62%	Privada

Média: 1,116691
σ : 0,206219



Source: the authors.

From a global point of view, it can be recognized that the levels of correctness associated with the knowledge of the natural sciences are not maintained according to the global average of students from public and private schools. While it is observed in the general analysis the distribution of grades of students from state schools, it is possible to perceive, in a very striking way, the number of students that do not exceed 600 points, totaling 616.339 of the 1.050.516 students, that is, about 58.67. When studying the distribution of general grades in natural sciences, the average peak of correctness of the Gaussian curve of students in state schools, it is noticed that the concentration occurs between 400 to 550 points, with an average of approximately 488 points. While candidates from the private network, in general, have an average peak around 565 points in natural sciences, and when analyzing the same range (up to 600 points), they have a representation of only 20.65% (57.565 of 278.747). This data are worrying, but indicate, as has already been treated by different authors in the area, the mismatch between public and private schools in Brazil (Libâneo, 2012) and the role of scientific knowledge in the school space (Archer et al.; 2015; Claussen & Osborne, 2012).

In order to seek ways of reflection, a relationship was found that demonstrated the potential for this research. To this end, an association of ENEM 2017 microdata with the 2017 School Census was made, both available on the INEP website[11]. This analysis was made based on the availability of the candidate's school code and an attempt was made to list possible indexes that would give clues in relation to infrastructure and teacher formation, giving some indications about the performance of students in the area of Natural Sciences. Again, it should be noted that candidates who were able to be analyzed were those who were present in the two days of the ENEM test and who were in the third year of high school. In addition, for this analysis, of the 1.384.929 initial students, 1.383.478 had a school code associated with the school census[12]. In this sense, of the 1.384.929 students, 763.387 of them had laboratories in their respective schools, 616.262 did not have laboratories in their respective schools, 3.829 students did not present information about the school infrastructure despite having a school code associated with the census, and 1.451 students did not have a code of school associated with the census.

Thus, of the 763.387 students whose schools had science laboratories, 37.689 were students from federal schools, 544.401 were students from state schools, 4.732 were students from municipal schools and 176,565 were students from municipal schools.

From the data it appears, in general, that as there is an increase in grades in Natural Sciences, the greater the representativeness of candidates who studied in a school that had a science laboratory and vice versa[13]. From the analyzed public, it highlighted the average number of students from federal system that has a science

11 INEP site, access to ENEM 2017 microdata and 2017 Schoolar Census: http://inep.gov.br/microdados.

12 Regarding the existence or not of laboratories at school, the 2017 School Census had three options: without laboratory, with laboratory or "empty", that is, no such infrastructure has been declared and, therefore, has not been accounted for in the percentages presented in this study.

13 It is observed that there is a percentage decrease in the presence of laboratories for cases above 700 points, however, as previously discussed, with representation in smaller absolute numbers.

laboratory in their schools which is 90.64%. Although it presents a slight decrease in the percentage rates of the presence of laboratories in the institutes, it is understood that this difference does not become impactful throughout all the studied ranges. Of the private school students 64.01% of them had laboratories in their schools within an increasing percentage as the grades increase. However, the case to be analyzed refers to state and municipal institutions. It is observed that the percentage rate of science laboratories in these institutions increase while students are able to obtain better performance up to 700 points in ENEM. Although percentage results are similar to those of private schools in terms of the rate of increase, the case is more serious when it is observed that in the range below 500 points there are in absolute numbers a significant value of students who are in the state sphere. It implies recognizing that more than half [14] of schools represented by 308.520 students[15] from state schools do not had natural science laboratory in their school[16].

Although in this article we do not aim at a mere correlation that "a better grade" in Natural Sciences comes from the presence of a laboratory at the school of that student, we believe it is a first opportunity for reflection from the 2017 data. In addition, the existence of a laboratory in a school does not necessarily mean that that candidate had practices in that space, however, the data indicate a possible school structure that provides possibilities and opportunities for different learning and experimentation for its students (Peregrino, 2010; Libâneo, 2012).

Corroborating this discussion, the 2017 School Census indicated that only 38.8% of state schools in the country have science laboratories, increasing to 57.2% in private schools and 83.4% in federal schools (Ministério da Educação, 2019). Fact that becomes more complex regarding the formation and working conditions of professionals of these areas (Alves & Pinto, 2011; Helene, 2013). It is worth remembering that about 42% of physics teachers in high school have formation in the area while, in the case of chemistry, there are approximately 62% of these professionals working in the specific disciplines of their training.

Given the numbers, there is a debate about how the university can be a "space of possible [17]" (Bourdieu, 2011; Archer et al., 2015) for students of public institutions and, also, as the scientific career can be a possible place to be entered when less than half of the institutions that form these students have a space destined to experimental activities.

14 Only 49.85% of schools have science laboratories according to data from the 2017 School Census and conditions applied in this study.

15 It is noteworthy that they are candidates present in the two test days, they were in the last year of high school in the state network and obtained performance less than or equal to 500 points in Natural Sciences and its Technologies. In addition, in this condition, there were 876 other candidates from state schools, such as those who did not declare whether or not they have a science laboratory ("empty" condition).

16 To interpret this data, it is necessary to take into account the corpus of the analysis and the number of schools that are represented by more than one student.

17 Term used by the author to define the set of provisions that mobilize the genesis of the social world and that indicate social and cultural investments for future profit in the invested social space. See more in "The practical sense" of Pierre Bourdieu (2011).

We emphasize the importance of the space in question when comparing the grades of federal schools, since, as discussed earlier, they are similar to the performance of private institutions, on average.

These results obtained according to the analysis of ENEM 2017 data aim to bring some discussions about the dimensions of cultural capital in the light of Pierre Bourdieu's theory and Charles Tilly's inequality. In this sense, elements associated with capital that dominate certain ways of conducting cultural practices or recognized by formal means that differentiate social classes are recognized. Greater representativeness of this discussion is found when it is recognized that:

> (…) people's income is heavily dependent on the quantity and quality of formal education they received; and, forming a vicious circle, the education of children and young people is also heavily dependent on their family income. The combination of these two factors makes our educational policy one of the main factors in the concentration of income and the reproduction of inequalities (Helene, 2013, p. 29).

When dealing with the vicious circle of income-education-income (Helene, 2013) it can be recognized that families with low economic capital conduct their relations with the school world in a pragmatic way, investing in the education of their children according to the daily dimensions that indicate successes and failures (Bourdieu & Passeron, 2013; Peugny, 2014; Peregrino, 2010).

Examples, such as the financial expense associated with private schools as opposed to public schools, end up leading to some considerations with regard to student performance (Helene, 2013; Peugny, 2014). Drawing a parallel, it is possible to look at the students who come from families that are willing to "pay" for an education as students with good cultural will and that implies, for example, investing in an institution whose school structure has its scientific laboratories:

> Cultural goodwill is expressed, among other things, by a particularly frequent choice of the most unconditional testimonies of cultural docility — choice of 'educated' friends, taste for 'educational' or instructive shows — often accompanied by a feeling of indignity ('the painting is good, but difficult', etc.), proportional to the respect given (Bourdieu, 2013, p. 300).

Cultural goodwill, therefore, is characterized by the recognition of legitimate culture and the systematic effort to acquire it. Families of the middle class and who have limited cultural capital undertook a series of actions (purchase of award-winning books, frequency of visits to cultural events) in order to acquire cultural capital (Nogueira & Nogueira, 2002).

It would be imprudent to state that students from private schools have better performance because of the school itself. We take a more careful look when we understand that these students come from families with good cultural will and, for that, end up having greater contact with capitals of interest to scientific culture and, precisely, perform better in tests such as ENEM (Bourdieu & Passeron, 2013; Krawczyk & Silva, 2017).

Science, its knowledge, is still little explored as an important asset to be worked on in macro-social terms, but it has, in our view, a fundamental role in the logic of maintaining the power of elites at the national level and which today lead to inequality linked to scientific and technological knowledge (Tilly, 2006). Science as a cultural arbitrary seems to indicate that the knowledge destined for the formation of students who will later be in positions of power, remains denied in public education (not totally, but in large part), placing the students of public institutions in situations of mismatch, almost always inferior, in the disputes for places in the consecrated and highly selective courses (Silva et al., 2011).

The result of these actions in practice appears in the proposal as the "training paths" in the New High School, which while aiming to pluralize the student's formation possibilities, in fact, they seem to indicate an important impact on the increase of inequalities in the long term by denying the teaching of natural sciences to economically and culturally less privileged students.

There is a light at the end of the tunnel. When observing the research data, the Natural Sciences seem to be an important means of reducing this distinction seen in the perspective of the role of this knowledge for the good performance of students from state schools. Still other analyzes need to be made in the long term to understand its historicity over the last few years, but a certain encouragement can be observed in defending that the natural sciences are characterized as an important markedly knowledge to guarantee public school students access to higher education. Using here, too, the possibility of scientific laboratories being these instruments that mediate learning that can support a good education to these students. It should be noted that a defense based solely on the data is not intended, but a look at the questioning of how the Natural Sciences can play an important role in reducing scientific-technological inequality (Tilly, 2006).

Conclusion and Implications

This article sought to promote a discussion on the role of scientific knowledge for social justice. As previously discussed, it was intended to understand how the knowledge of the sciences of nature behaves in the performance of students at ENEM and, consequently, in the future life of these students. The results showed that there is a relevant discrepancy between students from public state schools (n = 1.050.516) and private schools (n = 278.747) when these groups are observed in the range of hits greater than 600 points.

The analyzes indicated a low representation of young people from public schools in this range of success, which indicates a perception of social inequality and, consequently, educational, as shown by the performance of these students in ENEM 2017. While 221.182 (79,34%) of private school students score above 600 points, public state schools are represented by 434.177 students (41,32%). Nascimento et al. (2018) e Kleinke (2017) already point in this direction, in a way that it can potentially be recognized that there are indications that natural science issues are becoming an instrument of social reproduction and support the recognition of active socioeconomic aspects. on student performance.

Although the debate is not yet finalized, since it is recognized the need for further studies that make it possible to deepen the impact of the knowledge of the natural sciences on Brazilian global and regional inequality, on the behavior of these analyzes regionally and detailed studies of the performance ranges; the data showed that the performance of these young candidates in the natural sciences, comparatively, with the other areas of knowledge of ENEM, is remarkable in terms of the number of students who do not reach 600 points in this exam. There are 616.339 students from the 1.050.516 which have an average of 488 points while the average of private schools is 565 points in natural sciences. In this sense, even if it is recognized and should be debated whether every private school has educational quality and whether affirmative policies are addressing such a distinction, such as quotas for public schools, it is necessary to mobilize discussions that corroborate or seek to recognize the role which areas of knowledge, such as languages as a cultural capital, are becoming synonymous of good performance and social gain, as well as, the natural sciences have been behaving in the face of such reflections.

The attempt to start this debate can be perceived when students from public schools that have good scores have as one of their characteristics a high performance in natural sciences as opposed to the areas of human sciences. This does not happen with students from the private schools analyzed, as they perform better in the humanities than in the natural sciences. Emerges the discussion of the role of cultural capital for better performance in the humanities. This is because students from private schools, in large part, come from families that invest in the acquisition of cultural capital enabling "school success". On the other hand, the positive impact of natural sciences in the training of students in state schools indicates that performance in this area can constitute a means for the construction of the "spaces of possible" for these young students.

For Tilly (2006), scientific-technological inequality as a geopolitical instrument has shown itself to be increasingly impactful in terms of the distinctions and takeovers of large corporations and governments at the service of these capitalist institutions. For Bourdieu (1994), the role of the school institution is added to this debate. It is necessary to defend scientific knowledge as one of the factors that determines the cultural dimensions that are part of the structure of the ruling class and that is constantly denied to those who survive on the periphery of society and political power. Mobilizing such reflection, it can be seen that the knowledge of the natural sciences is not a mere curricular knowledge, but an instrument of power. In such a way that it is questioned in this study, how the knowledge of the natural sciences can effectively be recognized as important for the cultural elite or, at least, economically privileged, generating and maintaining the positions of power in society. Likewise, impacting public education and, subsequently, in the representation of these students in highly selective courses. It was in this context, that the analysis of ENEM 2017 may bring some reflections to mobilize indicative of its role in scientific-technological inequality and for social justice, seeking to recognize his role in the construction of proposals aimed to support the understanding of the Natural Sciences in student's formation and building a more just society.

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No potential conflict of interest was reported by the authors.

Compliance with Ethical Standards

The authors declare this study was conducted following ethical principles.