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Gender Inequality and Science Education: Comparison with Brazilian Students in PISA and ENEM

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ABSTRACT

Background: Natural sciences is considered a markedly masculine field of study. Despite the criticisms and changes observed in recent years, the effects on society of male science are still observed in school performance. **Objectives**: This study proposes to compare the performance inequality based on students' gender in the contents of natural sciences in Brazil at the end of two learning cycles, lower secondary education (LSE) and upper secondary education or high school (USE). **Design**: The research was designed to identify the size of the effect on the performance of male and female groups in the International Student Assessment Program (PISA) and in the National High School Exam (ENEM) between 2009 and 2018. **Setting and Participants**: Public school students who, in the year in which the exam was taken, were in their final year of LSE or USE. **Data collection and analysis**: PISA performance data were collected from the PISA Data Explorer. From ENEM, they came directly from the database made available by INEP. We applied statistical significance tests to identify differences in performance in the natural sciences test of the two exams. **Results**: The PISA results indicate that there is no difference in the students' performance based on gender. In contrast, the ENEM results indicate a difference of 0.3 standard deviations in favour of boys. **Conclusions**: The results point to an expansion of the gender-based differences in the contents of natural sciences during the EM.

Keywords: Gender inequality; Science education; PISA; ENEM; Brazilian students.

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Gênero e Ensino de Ciências: comparação com estudantes brasileiros no PISA e ENEM

RESUMO

Contexto: As Ciências da Natureza é considerada uma área de estudos marcadamente masculina. Apesar das críticas e mudanças observadas nestes últimos anos, os efeitos sobre a sociedade da ciência masculina ainda são observados com relação ao desempenho escolar**. Objetivos**: Este estudo propõe comparar a desigualdade de desempenho em relação ao sexo dos estudantes nos conteúdos de Ciências da Natureza no Brasil, ao final de dois ciclos de aprendizagem, Ensino Fundamental II (EFII) e Ensino Médio (EM). **Design**: A pesquisa foi desenhada para identificar o tamanho do efeito no desempenho dos grupos masculino e feminino no Programa de Avaliação Internacional de Alunos (PISA) e no Exame Nacional do Ensino Médio (ENEM) entre os anos de 2009 e 2018. **Ambiente e participantes**: Os estudantes de escolas públicas que no ano de realização do exame estavam cursando o último ano do EFII ou o EM. **Coleta e análise de dados**: Os dados sobre rendimento no PISA foram coletados a partir do PISA Data Explorer. Do ENEM vieram diretamente do banco de dados disponibilizado pelo INEP. Aplicamos testes de significância estatística para identificação das diferenças de desempenho na prova de Ciências da Natureza dos dois exames. **Resultados**: Os resultados do PISA indicam que não há diferença no desempenho em relação ao sexo. Em contrapartida, os resultados do ENEM indicam uma diferença de 0,3 desvios padrão a favor dos meninos. **Conclusões**: Os resultados apontam para uma expansão das diferenças em relação ao sexo nos conteúdos de Ciências da Natureza durante o EM.

Palavras-chave: Desigualdade de gênero; Ensino de Ciências; PISA; ENEM; Estudantes Brasileiros.

INTRODUCTION

This study discusses the performance inequality based on students' gender at the end of the lower secondary education (LSE) and upper secondary education (USE) or high school in Brazil in the contents of natural sciences. International studies present expressive results on the differences in academic performance between sexes in the contents of natural sciences and mathematics (Stoet & Geary, 2019; Rachmatullah & Ha, 2019; Stoet & Geary, 2018; Burgoa Etxaburu, 2017; Nissen & Shemwe, 2016; Wilson et al., 2016; Han, 2015; Casagrande & Carvalho, 2010; Hyde et al., 1990; Aylon & Liveh, 2013; Pahlke, Hyde & Linn, 2013; Ryan & Demark, 2002). The results show a better performance of men in these areas compared to women.

In Brazil, different works point to results such as those observed in international studies (Carvalho & Lorencini Junior, 2018; Marcom & Kleinke, 2017; Silva, Barbosa & Souza, 2015; Casagrande & Carvalho, 2010). However, some research, mainly in mathematics, has shown that even in a school-age group of students, this distinction in performance is not observable, especially in LSE (Casagrande & Carvalho, 2010). According to these investigations, there are no differences between boys' and girls' performance and learning until the end of LSE in Brazil, specifically in the age group of 14 and 15 years. At the international level, similar results are observed in the work of Hyde et al. (1990) and Randhawa (1991), who show how in middle school (up to the age of 14), students' gender does not influence their school performance.

However, after that, these differences become statistically significant, in favour of men, principally in the areas of natural sciences and mathematics, throughout high school and in large-scale assessments (Nissen & Shemwe, 2016; Wilson et al., 2016; Han, 2015; Aylon & Liveh, 2013; Hyde & Linn, 2013; Ryan & DeMark, 2002; Hyde et al., 1990). These studies show how the differences in performance range between 0.2 to 0.3 standard deviations in favour of men in these contents. The results are statistically significant and, in some cases, can be considered a moderated distinction between the groups.

These gender differences are also observed in higher education (Eddy & Brownell, 2016; Day et al., 2016; Nissen & Shemwell, 2016). According to the researchers, there are gaps in school results in introductory physics courses. In the case of introductory courses, Nissen & Shemawell (2016) concluded that the experience of teaching physics decreases women's self-efficacy, so the authors corroborate the idea that a change in traditional education is necessary to correct inequalities.

Another educational activity in which significant differences in performance between men and women are observed is the Olympics and assessments, specifically in physics. Wilson et al. (2016) show a significant gender difference in Australia. According to the authors, men and women respond differently. In the same way, in most questions, students perform better than students in the different types of items (Wilson et al., 2016).

In this sense, this article compares differences in boys' and girls' performance in natural sciences content in Brazil at the end of two learning cycles. For this, we will use two sources of information: Brazil's results in the Program for International Student Assessment (PISA) and the National High School Examination (ENEM) between the years 2009 to 2018.

WHAT IS PISA AND ENEM?

Created at the end of the 1990s, the Program for International Student Assessment (PISA) is a device for the international comparative evaluation of school performance that has been one of the primary means of the action of the Organization for Economic Cooperation and Development (OECD) in the educational field (Carvalho, 2009). The agency presents it as a study that aims to respond to the demands of the member countries, in the sense that, regularly, they have reliable data on the knowledge and skills of their students and, consequently, on the performance of their education systems.

The purpose of PISA goes far beyond simply monitoring the current state of learning. “PISA information should allow policymakers to see what factors are associated with educational success, and not just compare results in isolation” (Schleicher, 2006, 23). The design of the programme and the methods underlying the preparation of the final reports of each study are presented as dependent on governments’ needs to draw policy lessons from it about the quality of learning outcomes, equity in learning and equity in educational opportunities, the effectiveness and efficiency of educational processes and the impact of learning outcomes on social and economic well-being (Schleicher, 2006).

PISA provides information on the performance of 15-year-old students, the age at which compulsory education is supposed to be completed in most countries, linking data on their backgrounds and attitudes towards learning and factors keys that shape their learning, inside and out of school. According to the OECD (2017), students between 15 years and three months (complete) and 16 years and two months (complete) are eligible to take the exam at the beginning of the assessment application period, enrolled in educational institutions located in the participating country, from the 7th year of primary school onwards.

Table 1

Number of participants in the historical series in Brazil

Year	**2000**	**2003**	**2006**	**2009**	**2012**	**2015**	**2018**
Participants	4,893	4,452	9,295	20,127	18,589	23,141	10,691

To carry out the sample selection, the OECD creates a sampling plan that can be understood as the description of the method to be adopted to select the sample elements. In PISA, the OECD defines the sampling plan to allow the comparability of results between countries. In this process, the OECD creates a stratification system that allows the selection of the sample so that it faithfully represents the Brazilian school population within the range of application of the test. Once the schools have been selected, the eligible students are chosen randomly, with an equal probability of selection, using software developed by the international consortium.

The exam assesses three domains (reading, mathematics, and science) in each edition or cycle. With each edition, the main domain is assessed, which means that students answer more test items in that knowledge area and that the questionnaires focus on collecting information related to learning in that domain. The survey also assesses so-called innovative domains, such as problem-solving, financial literacy, and global competition.

The National High School Examination (ENEM) was created in 1998 to evaluate general education at the end of high school, and this general education could be understood as training with the basic skills necessary for the exercise of citizenship. However, within a reform of the federal university policy (REUNI), which began in 2007 and included the expansion of vacancies, the creation of new university courses, and changes in access to federal public higher education (quota law and the unified system of vacancies, Sisu), the role of the ENEM was completely modified, becoming the national entrance exam to federal universities, among other functions. The ENEM is undoubtedly the most important exam in Brazil. This exam is also considered the second largest selection process in the world, only behind the Chinese selection process for admission to university education.

The exam is not mandatory; it is used for multiple purposes such as, (i) it is the only point of entry to free higher-education federal institutions; (ii) can grant scholarships in private institutions; (iii) gives the possibility of graduating from high school, if the student is over 18 years of age and for some reason left the educational system. Not only students who are finishing high school take the test, but also students who have already finished high school and students in the middle of high school also take the ENEM for practice. In other words, it is possible to do ENEM as often as Brazilian students want. However, it is only possible to access higher education once the person has finished high school.

ENEM consists of two days of testing. In total, there are 180 multiple-choice items plus an essay. There are 45 subjects for each academic discipline: mathematics, languages (Portuguese and Spanish or Portuguese and English), natural sciences, and humanities. The first day consists of natural sciences and humanities in a 4h30min exam, and the second day consists of mathematics, languages, and an essay in a 5h30min. Therefore, each day students take 90 multiple-choice problems. We should point out that if students spend an hour on the essay, they will have 4h30 for 90 questions, an average of 3 minutes for each question, and since most of the issues contain text and/or tables or graphics, the lack of time for the reasoning of the problems can lead to a random guess. For the admission process, the score of each area is treated based on the item response theory (IRT), which tries to minimise the effect of random guesses.

As a way of guaranteeing the relevance of our results, we identified the percentage of students graduating from high school in public education, according to the school census, about graduating students who participated, in full, in the ENEM in 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017 and 2018 (sample). These data are presented in Table 2.

The data presented in Table 2 help the reliability of the developed analyses, as they allow a significant analysis of high school students throughout Brazil. The variation observed in percentage may be explained by different aspects of socioeconomic changes in the population, political instability, and changes in the registration fee for the test, among others. The importance of these data is an example of the amplitude of the exam.

Knowing the dimensions of this exam, we seek to understand how the ENEM became what it is today. We observed that due to the University for All Program (PROUNI) - a programme for obtaining scholarships for private universities, the ENEM has had significant growth in the number of participants, reaching more than three million participants in one year (Aguiar, 2016). As for the REUNI, drastic changes occurred in the exam, with its total redefinition in 2009. This transformation brought the exam closer to the old selection process, thus transforming the ENEM into a more summative assessment. Another government policy that affected student participation in ENEM was the Quota Law, which reserves 50% of vacancies in federal public universities for students from public schools (Marcom & Kleinke, 2021). This policy appears as a way to expand access to public higher education for the lower classes. This policy fostered growth of approximately one million subscribers soon after this law, showing that this governmental action interfered with the exam indirectly (Marcom & Kleinke, 2021).

Table 2

Year of ENEM, number of public high school graduates participating in ENEM, number of public high school graduates and percentage.

Year	Graduates Participants ENEM of Public High School	Graduates of Public High School	%
2009	947,592	1,525,289	62
2010	1,109,808	1,522,379	73
2011	1,227,288	1,549,611	79
2012	970,548	1,580,685	61
2013	1,087,196	1,770,523	61
2014	1,127,400	1,780,380	63
2015	1,170,404	1,738,550	67
2016	1,225,012	1,816,939	67
2017	1,037,660	1,764,539	60
2018	1,104,937	1,640,916	67

All these actions led ENEM to what it is today, an exam of high social demand whose main function is to rank candidates for the selection processes present in public and private universities. Despite this characteristic, ENEM can also be a very rich source of information because the analysis of the exam microdata allows the development of knowledge about the progress of basic education skills.

Both exams have different characteristics of structuring, however, they have common goals, e.g., evaluated skills of conceptual knowledge about different areas. Given the sample profile of the two exams, it is possible to produce good results in education at the end of the two cycles investigated using the available data. To think of external evaluations as instruments for teaching is to look at the possibility of developing correlations between what is being developed in the classroom with extracurricular issues that directly interfere with the learning of young people. From those correlations, we can reflect on how each instance of the educational system will act from the results of the assessments.

SOCIOLOGY OF EDUCATION AND GENDER STUDIES

To analyse the data from this research and produce conjectures about how gender differences become more evident in school performance, we decided to use Pierre Bourdieu's works, which focus on describing how society builds, reproduces, and transmits some social standards, mainly through symbolic violence.

This concept illustrates how some cultural values are perpetuated and imposed. Its effects tend to be more psychological. Symbolic violence differs from physical violence, although it can ultimately be expressed in this form. It assumes that, although they sometimes seem universal, the symbolic systems (culture) shared by a given social group are arbitrary since they vary from time to time and from society to society. When put into practice, symbolic violence legitimises the dominant culture, which is imposed and ends up being naturalised. Upon reaching this last stage, dominated individuals can no longer respond or oppose with sufficient force; often, they do not even see themselves as victims, feeling that their condition is something that cannot be avoided.

For Bourdieu, male domination within our society occurs through symbolic domination, which "[...] is exercised not in the pure logic of cognitive consciousness, but through perception, evaluation and action schemes. that are constitutive of the habitus and that underlie, beyond the decisions of the conscience and the control of the will, a relationship of knowledge profoundly obscure to itself" (Bourdieu, 2010, 50).

Thus, relations of domination are not easily perceived since, as the author points out, one must consider the lasting effects of the social order on women (Bourdieu, 2010). More explicitly, it is necessary to understand how symbolic relationships present in our society are transmitted and thus configure physical, cognitive, and psychological characteristics in men and women.

Different studies on gender and social representations help us to observe how men and women are perceived symbolically affected in different groups of society, workspaces, and others (Kang et al., 2019; Hanson, Sykes & Pena, 2017; Heerdt & Batista, 2017; Foote & Garg, 2015; McCullough, 2011). These effects occur mainly at the affective level, so women's career choices in science and engineering are affected (Kang et al., 2019; Hanson, Sykes & Pena, 2017; Foote & Garg, 2015; McCullough, 2011). In this way, the effects of male symbolic dominance become explicit and long-lasting since work on this topic has been published for over three decades (Sardenberg, 2001; Kenway & Gough, 1998; Lopes, 1998; Oreske, 1996). When reflecting on the symbolic issues present in society, it is necessary to understand how school has a fundamental role in this reproduction process (Bourdieu & Passeron, 2008).

For Bourdieu and Passeron (2008), the relationships within school settings are governed by the relationships existing in symbolic violence. “All power of symbolic violence, that is, all power that manages to impose meanings and impose them as legitimate, hiding the relations of forces that are at the base of its force, adds its force, that is, properly symbolic, to these relations of power” (Bourdieu & Passeron, 2008, 25).

This occurs within the school through the symbolic domination exercised by the teaching body, which transmits to the students the knowledge that was defined as “natural” and “true” by those who control the structures of society. Thus, those who suffer this violence unconsciously validate them in the same way as teachers.

This symbolic violence process occurs in all students (again lacks inclusive language). However, its imposition is stronger on individuals who do not belong to the dominant classes, being further away from the dominant culture considered legitimate by the school. This detachment forces individuals to make more effort to achieve academic success, so those who do not know these symbols find it harder to understand them (Bourdieu & Passeron, 2008). Therefore, through symbolic violence, the school reproduces social structures that interfere with student learning, culminating in performance distinctions between groups and large-scale evaluations.

An example of how it happens at school is when students from specific regions or in marginalised socio-cultural conditions are discriminated against for speaking differently from what is defined by prescriptive grammar as being “the correct way” of expressing the language. This discrimination also on the part of teachers and other employees spreads what is understood as linguistic prejudice. Thus, the school becomes a violent and highly unpleasant place for those students, who continue to attend classes with their heads down or drop out, believing that their linguistic expression and, consequently, their culture are naturally lesser.

Unlike other forms of violence in which the victim perceives their suffering and can easily identify their aggressor, symbolic violence is not so simple. Symbolic violence, as the concept suggests, is accomplished through symbols, especially in the way we communicate. Victims are not just individuals, but social groups and aggressor agents reproduce social structures in a systematic and not intentionally, violent way. In this logic, it is important to emphasise the role of the school as an institution that is aware of this violence and an agent to prevent its perpetuation.

In the case of gender relations, Valle Silva (1995) shows how the model of social reproduction through cultural capital is different for boys and girls, an example of which is the emphasis on literary culture for women and an emphasis on scientific culture for men (Bourdieu, 2007). For Bourdieu, from childhood, boys receive with more emphasis specific cultural characteristics and skills in natural sciences, while girls receive them from linguistics. This means that the entire symbolic model linked to natural sciences is more easily recognised by boys, unlike girls who, socially and culturally, move away from those symbols and values. In this way, girls suffer more from the effects of the symbolic violence of natural sciences and their disciplines: physics, chemistry and biology.

To understand the symbolic role of the natural sciences in gender studies, it is necessary to identify how these problems are observed in society. Studies on gender issues within natural sciences are essential to understand how this area of knowledge has carried out and continues to carry out this process of exclusion of women historically.

Those works appear to verify the absence of women in natural sciences and its causes (Lopes 1998; Keller & Scharff – Goldhaber, 1987). The results of these works end up promoting a critique of gender neutrality in natural sciences, which, according to Sardenberg (2001), was enunciated in the 1930s by Virginia Woolf. For Woolf, the science of nature was a non-asexual and mainly masculine being (Sardenberg, 2001). Such a figure in the natural sciences as a masculine being was corroborated by Oreskes (1996), indicating the maintenance of gender characteristics in this area of knowledge.

Soares (2001) shows men’s predominance in natural sciences. The author works with the idea that the low rates of women in science and technology are related to institutional standards that influence the success or failure of individuals. Thus, we can assume that this masculine environment in which natural sciences is taught may affect women’s entry and permanence in this environment (Tannenbaum et al., 2019; Sofiani et al., 2017; West et al., 2013). In the area of engineering, in several countries, labour problems related to gender arise (Han, 2016; Sanchis-Segura et al., 2018; Stoet & Geary, 2018). Large companies in the field of engineering are looking for male workers (Sanchis-Segura et al., 2018). Gender differences in career interests also contribute to women's underrepresentation in fields such as mathematics and the natural sciences (Pitan & Atiku, 2017; Williams & Mangan, 2016; Sardenberg, 2001; Lopes, 1998).

Works directly related to school and education (Rachmatullah & Ha, 2019; Sanchis-Segura et al., 2018; Burgoa Etxaburu, 2017; Nissen & Shemwe, 2016; Wilson et al., 2016; Han, 2015; Casagrande & Carvalho, 2010) show how these differences are strongly present in the classroom - interfering in the learning process and forcing girls to try harder, to have the same conditions as boys. We believe that this effort is directly related to issues of symbolic violence. In the case of the natural sciences, which historically developed in a male environment, symbolic production will be directly related to this group, in this case, the ruling class. From Bourdieu's (2010) perspective, the male domination present in this social environment formed segregation of women in this space, so they needed to work much harder to obtain the symbolic domain of natural sciences, as well as the same academic recognition (Hanson, Sykes, & Pena, 2017; Nissen & Shemwe, 2016; Wilson et al., 2016; McCullough, 2011; Casagrande & Carvalho, 2010). Finally, it is possible to see this symbolic domination in teachers and their social representations of gender issues in natural sciences (Heerdt & Batista, 2017) and the teaching materials used by students (Bandeira & Velozo, 2019; Martins & Hoffman, 2007).

THE BRAZILIAN EDUCATIONAL SYSTEM AND THE TRAINING OF SCIENCE TEACHERS

The Brazilian educational system can be divided into four educational stages. The first is called early childhood education, which includes the process of schooling in early childhood and second childhood (between 0 and 5 years). The second stage is called primary education, consisting of five years of schooling. This cycle serves children between 6 and 11 years old (Brazil, 1996). One of the main characteristics of this cycle is the presence of a teacher who has the function of teaching a varied set of subjects in the areas of mathematics, natural sciences, humanities, and languages (Brazil, 1996).

Lower secondary education follows, with students between 12 and 15 years old. One of the main differences between primary and lower secondary education is that at this level, the teacher has a specialisation in teacher training. In the first cycle of primary education, most teachers majored in pedagogy. For this third cycle, the teacher must be a specialist in their area (Brazil 1996). In the case of natural sciences, low secondary education teachers usually majored in biology or natural sciences (Brazil, 1996). In high school, teachers that teach subjects in the natural sciences are generally trained in physics, chemistry and biology courses.

The education system has distinct disciplines for natural sciences. In this case, this training is structured from a set of disciplines on the contents of the natural sciences (physics, chemistry, and biology) and educational sciences, integrative disciplines between the areas and 400h of supervised teaching practice.

High school is a stage that corresponds to the end of compulsory education in Brazil. The age range of the students varies between 15 and 18 years. High school can carry out a concomitant professional education. There is also youth and adult education (EJA) for those who did not have the opportunity to study at the appropriate time, which usually takes place at night. Schools generally work in three shifts, mornings (7:00 a.m. - 12:30 p.m.), afternoons (1:00 p.m. - 6:30 p.m.) or nights (7:00 p.m. - 11:00 p.m.) (Fernandez, 2018). Thus, the same building is used in all three shifts, and the number of students per class generally varies from 35 to 50 (Corio & Fernandez, 2010). In addition to the shifts and the number of students per class in high school, another important factor is the low rates of teachers trained in the same subjects they teach. According to data from the school census, between 2013 and 2016, 40% of teachers did not have a degree in the subject they teach (Costa & Bollmann, 2018).

This overview of high school characteristics in Brazil helps us understand some of the difficulties associated with basic education, which will directly reflect on teachers' work in this education cycle. At the end of this cycle, approved students can seek places in higher education courses through entrance exams to access Brazilian universities.

METHODOLOGY

This work aims to compare the performance between boys and girls in natural sciences content at the end of two learning cycles, primary education II (15 years) and high school (18 years). We chose to use information from two different sources, the Program for International Student Assessment (PISA) and the National High School Examination (ENEM). PISA data was used to analyse whether there is statistical significance between boys and girls who finished primary school. The choice to use the PISA data is related to the fact that in Brazil, there is no large-scale assessment to measure knowledge in natural sciences content in this learning cycle. PISA data was collected directly from its online platform PISA DATA EXPLORER (available: https://pisadataexplorer.oecd.org/ide/idepisa/), through which the statistical significance between boys and girls was calculated using the T-student statistical test.

Initially, the T-student (t-test) was developed to examine the differences between two independent and small samples, which have a normal and homogeneous distribution of their variances (Sánchez Turcios, 2015). In the case of this research, our objective is to compare the mean of two independent groups; thus, we applied the t-test for independent samples. This argument allows us to identify whether there are significant differences between the samples. However, it does not allow us to identify the size of the effect of such discrepancy so that other tests will be applied. Therefore, we chose to apply Cohen's distance.

This test allows the statistical distance between samples to be measured in standard deviation units (Cohen, 1988). We chose this test because it is easy to use and interpret its results. Thus, to measure the statistical distance between two groups, we can use equation (1) described below:

$$d = \frac{M_f - M_r}{DP_{rf}} \qquad (1)$$

where d is what is conventionally called Cohen's distance; M_r and M_f are the reference and focal sample averages, respectively. DP_{rf} is the standard deviation for the total population, formed by the union between the focus and reference groups. The d values can be positive and negative, depending on the mean of the focus group and the reference group. Thus, if the d value is positive, it means a better performance of the focus group compared to the reference group. If the d value is negative, it means that the performance of the reference group is better than that of the focus group. In the literature, we find a series of works that use this test to compare groups, such as differences in performance according to gender (Hyde & Linn, 2006; Ryan & DeMark, 2002.)

To identify whether the difference between the compared groups is significant, we agreed on a metric to analyse the values of d (Cohen, 1988). However, the definitions of the distance ranges can vary according to the number of people that make up the data; in our case, we have many candidates that make up the data, and our scale is like that of jobs with many individuals (Aylon & Liveh, 2013; Hyde & Linn, 2013; Ryan & DeMark, 2002).

For high school graduates, we used ENEM data (available: https://www.gov.br/inep/pt-br/acesso-a-informacao/dados-abertos/microdados/enem). This exam is held annually for students who complete or have already completed high school in Brazil, with two well-defined objectives: I) to be an instrument for the selection of candidates for higher education courses in Brazil, and II) to evaluate the knowledge of the student graduated from High School (Brazil, 2009). Unlike PISA, ENEM consists of four tests on the contents of languages, mathematics, natural sciences, human sciences, and an essay. In total, there are 180 multiple-choice items given over two exam days. The data used for this research is available on the website of the National Institute for Educational Research "Anísio Teixeira" (INEP). To calculate the statistical significance between the groups, using the T-student test, the Statistical Package for the Social Sciences (SPSS v. 22) statistical software was used.

RESULTS AND ANALYSES

To start the discussion of the data, we will present the PISA data first, representing the analysis of primary school students. Table 3 shows the average of the two groups and the standard error associated with this measure in each year of PISA, 2009, 2012, 2015, and 2018.

Table 3

The average performance of PISA X Gender for 2009, 2012, 2015, and 2018 in Brazil.

Year	Gender	Average	Standard Error
2009	Boys	407	2.6
	Girls	404	2.6
2012	Boys	402	2.3
	Girls	401	2.2
2015	Boys	403	2.5
	Girls	399	2.4
2018	Boys	403	2.5
	Girls	404	2.1

The data in Table 3 indicate a slight difference between the means of boys and girls. However, when applying the statistical significance test, the results show that only in 2015 there was a small difference in the results. The T-Student test resulted in a value of 4 (p-value = 0.0118), which indicates a better performance of the children in that year. To measure the importance of this difference, Cohen's distance was calculated for that year (d = 0.14). This result for d indicates a distance between the boys that exceeds the girls by 0.14 standard deviations. On Cohen's scale, this represents a small but significant difference between the groups. As in 2009, 2012, and 2018, there was no statistically significant difference between the groups, we can consider that the results agree with what the literature already expected (Casagrande & Carvalho, 2010; Hyde et al., 1990; Randhawa, 1991; Ma, 1999).

Table 4

The average performance of ENEM X Gender for 2009-2018.

Year	Gender	Average	Standard Error
2009	Boys	520.04	0.33
	Girls	487.10	0.25
2010	Boys	499.54	0.26
	Girls	476.83	0.19
2011	Boys	482.06	0.25
	Girls	457.24	0.19
2012	Boys	466.36	0.23
	Girls	444.76	0.16
2013	Boys	486.40	0.21
	Girls	464.99	0.16
2014	Boys	480.26	0.20
	Girls	463.55	0.15
2015	Boys	495.26	0.20
	Girls	468.39	0.15
2016	Boys	441.08	0.41
	Girls	423.98	0.33
2017	Boys	520.55	0.20
	Girls	503.13	0.16
2018	Boys	441.08	0.41
	Girls	423.98	0.33

Therefore, we must consider that the hypotheses raised about the low or null differentiation of performance between genders until the end of primary school in Brazil are true. Consequently, it is important to investigate what school and non-school factors (economic, social and affective) prevent this differentiation from occurring in the discipline of natural sciences.

Regarding the results for high school graduates, Table 4 describes the average of the two groups and the standard error associated with this measure in each ENEM, between 2009 and 2018.

The data in Table 4 indicate, first, that women's performance is always lower than that of men in the natural sciences test in all the years studied. This first result could be considered an indicator of a gender difference in high school in Brazil. However, for such a statement to be better analysed, it is necessary to apply the T-student test to these data. The application revealed that in all years, there is a significant difference in favour of men about women's performance in the natural sciences test. So, this distance between the two groups was measured from the value of d, and the results are presented in Table 5.

Table 5

ENEM data for 2009 through 2018: T-Student and Cohen's d.

Year	T-Student	*d*
2009	78.76	0.33
2010	70.75	0.28
2011	78.56	0.29
2012	75.93	0.32
2013	81.27	0.29
2014	66.90	0.26
2015	107.90	0.38
2016	32.54	0.11
2017	68.97	0.26
2018	32.54	0.11

$p < 0.01$

Table 5 show that, over the years, the distances between the groups always remain statistically significant, with some variations in the degree of the distances, between moderate and small. Only in 2016 and 2018 are the d values considered a small difference. Therefore, the results presented in Table 5 align with what has already been presented in the international literature on the subject (Aylon &Liveh, 2013; Hyde & Linn, 2013; Ryan & DeMark, 2002).

On the one hand, gender studies in natural sciences point out that women are underrepresented in this area of knowledge (Nissen & Shemwe, 2016; Wilson et al., 2016; Casagrande & Carvalho, 2010; Kenway & Gough, 1998). This lack of representativeness occurs through symbolic violence in teachers' social representations (Heerdt & Batista, 2017) and the symbolism in science books (Martins & Hoffmann, 2007).

This is a result that researchers should further explore to modify these long-lasting structures in our society. More than the action of academics, these results must be returned to teachers as a way of promoting actions that break with stereotypes established in the school environment (Marcom & Kleinke, 2021). This resumes our main idea of the formative role of large-scale assessment, in which the formative action takes place in the identification, construction and return of this information to the classroom and changing the position of the school community to improve students' learning.

In the case of the gender differences, the knowledge of this information described here associated with the knowledge of the action of symbolic violence on girls can help the teacher make changes in their practices that reduce this violence and allow easier access to these girls' knowledge.

The presented data should serve as an alert and source of information about the symbolic gender violence in society. Their analysis shows that any other biological factors that could differentiate students of different genders are less significant than the social factors expressed in symbolic violence. Relating academic performance data with gender is a perfect opportunity to reflect on how symbolic violence has interfered in the school environment. We cannot ignore that symbolic gender violence is structured in a conception of men's superiority over women. In academic performance, this notion can interfere directly with the interests of young people, girls and boys, and indirectly, through the expectations created about students' performance according to their gender.

CONCLUSIONS

In this article, we compare the performance of boys and girls in large-scale assessments at the end of two teaching cycles in Brazil, first, in lower secondary education and second, in high school. For our analysis of the performance in the contents of natural sciences at the end of lower secondary school, we used the results of Brazil in PISA from 2009 through 2018. According to the PISA data, only in 2015 did we observe a significant difference in performance in favour of boys in the contents of natural sciences.

This result helps to corroborate the hypothesis that, up to this school level, the gender of children does not influence their school performance.

However, when we look at student performance at the end of the next school cycle, high school, we see that differences in performance are evident between boys and girls. According to the data presented in the T-student statistical test, for all the analysed years, we observed significant differences between the groups. To understand the size of the effect of this difference between genders, we applied Cohen's distance, which revealed that the differences are considered moderate in 80% of the years analysed. In the other 20%, the differences are considered small but significant. These results indicate that, throughout the three years of high school, the performance differences between boys and girls in natural sciences content are increasing significantly.

This result reflects how a social characteristic interferes with the participants' performance so that we observe the evident reproduction described by Bourdieu and Passeron (2008) of society in science and science teaching. Works like Marcom and Kleinke's (2021) and Nissen and Shemwe's (2016) indicate how the entire social construction of boys and girls interferes with the performance of an item, which can also interfere with the development of learning.

Although our results are not yet conclusive about the origin of the differences observed during the secondary schooling process, we suppose that these inequalities may be associated with different historical factors, the historical constitution of natural sciences as a masculine environment, as brought by the author's Lopes (1998) and Soares (2001), or even more general issues such as the wage gap between men and women. The works by Bourdieu (2007) and Valle Silva (1995) can offer a solid theoretical framework to understand this differentiation, saying that if the process of transmitting the characteristics of a group takes place through culture, consequently, it is a historical process. Therefore, we can infer that the emphasis on scientific culture given to boys throughout their lives expands their possibilities of performing better than girls in an assessment such as the ENEM.

We believe those differences are amplified due to a series of school and social factors existing in high school in Brazil. Therefore, it is necessary to investigate more deeply the observed differences. Thus, they generate essential information for work in the classroom, bringing about changes in teaching so that gender inequalities can be corrected (Nissen & Shemwe, 2016).

AUTHORS' CONTRIBUTIONS STATEMENTS

G.S.M. and T.Z.B.A. conceived the presented idea. G.S.M. developed the theory and adapted the methodology to this context, created the models, performed the activities, and collected the data. G.S.M. and T.Z.B.A. analysed the data. All authors actively discussed the results and reviewed and approved the final version of the work.

DATA AVAILABILITY STATEMENT

The data supporting the results of this study will be made available by the corresponding author, G.S.M., upon reasonable request.

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