EDUCAÇÃO EM FOCO
PROGRAMA DE PÓS-GRADUAÇÃO EM EDUCAÇÃO | UNIVERSIDADE DO ESTADO DE MINAS GERAIS

Capital de ciências e desempenho em ciências: um estudo quantitativo usando dados de larga escala

Carlos Henrique Aparecido Alves MORIS[1]
Matheus Monteiro NASCIMENTO [2]
Luciana MASSI [3]

RESUMO
O conceito de capital de ciências, baseado na teoria de Bourdieu, relaciona o interesse por ciências aos meios de socialização. Contudo, a rentabilidade do capital de ciências foi pouco investigada empiricamente. Utilizando análise fatorial, regressões lineares multivariadas, e análise de correspondência em aproximadamente 350 mil candidatos do Exame Nacional do Ensino Médio, construímos um índice de capital de ciências para o contexto brasileiro e testamos sua rentabilidade a partir da prova de ciências da natureza. O capital de ciências explicou as diferenças de candidatos com capitais cultural e econômico semelhantes, sendo o capital de ciências associado com melhores desempenhos. Contudo, a análise de correspondência mostrou que os maiores desempenhos não estão alinhados ao maior volume de capital de ciências. Demonstramos o potencial do capital de ciências em explicar a influência de desigualdades sobre o desempenho em ciências, ainda que o conceito apresente algumas incoerências com a teoria bourdiana de capitais.

PALAVRAS-CHAVE: Capital de ciências. Classe social. Desempenho. ENEM. Fatores socioeconômicos.

[1] Mestre e Doutorando em Educação em Ciências. Programa de Pós-Graduação em Educação para a Ciência, da Faculdade de Ciências da Universidade Estadual Paulista, Bauru. Orcid: https://orcid.org/0000-0002-7772-1071. E-mail: carlos.moris@unesp.br
[2] Doutor em Ensino de Física. Professor do Instituto de Física da Universidade Federal do Rio Grande do Sul. Orcid: https://orcid.org/0000-0001-8179-5391. E-mail: matheus.monteiro@ufrgs.br
[3] Doutora em Ensino de Química. Professora associada do Departamento de Educação da Faculdade de Ciências e Letras de Araraquara e do Programa de Pós-Graduação em Educação para Ciência da Faculdade de Ciências de Bauru da Universidade Estadual Paulista. Orcid: https://orcid.org/0000-0001-8761-3181. E-mail: luciana.massi@unesp.br

EDUCAÇÃO EM FOCO
PROGRAMA DE PÓS-GRADUAÇÃO EM EDUCAÇÃO | UNIVERSIDADE DO ESTADO DE MINAS GERAIS

Science capital and students' achievement in science: a quantitative study using large-scale data

Carlos Henrique Aparecido Alves MORIS
Matheus Monteiro NASCIMENTO
Luciana MASSI

ABSTRACT
The concept of science capital, based on Bourdieu's theory, connects interest in science with socialization processes. However, the profitability of science capital has been little explored empirically. Using factor analysis, multivariate linear regressions, and correspondence analysis on data from approximately 350,000 candidates of the National High School Exam (ENEM), we developed a science capital index for the Brazilian context and tested its profitability using the Natural Sciences exam. Science capital explained performance differences among candidates with similar cultural and economic capital, being associated with better results. However, correspondence analysis revealed that higher performance does not necessarily align with greater volumes of science capital. Our findings demonstrate the potential of science capital to explain the influence of inequalities on science performance, although the concept exhibits certain inconsistencies with Bourdieu's theory of capital.

KEYWORDS: Educational test performance. ENEM. Science capital, Social class. Socioeconomic factors.

EDUCAÇÃO EM FOCO
PROGRAMA DE PÓS-GRADUAÇÃO EM EDUCAÇÃO | UNIVERSIDADE DO ESTADO DE MINAS GERAIS

Capital científico y desempeño científico: un estudio cuantitativo que utiliza datos a gran escala

Carlos Henrique Aparecido Alves moris
Matheus Monteiro NASCIMENTO
Luciana MASSI

RESUMEN
El concepto de capital científico, basado en la teoría de Bourdieu, conecta el interés por la ciencia con los procesos de socialización. Sin embargo, la rentabilidad del capital científico ha sido poco explorada empíricamente. A través de análisis factorial, regresiones lineales multivariadas y análisis de correspondencia en aproximadamente 350.000 candidatos del Examen Nacional de Educación Secundaria (ENEM), desarrollamos un índice de capital científico para el contexto brasileño y evaluamos su rentabilidad utilizando el examen de Ciencias Naturales. El capital científico explicó las diferencias de desempeño entre candidatos con niveles similares de capital cultural y económico, estando asociado con mejores resultados. Sin embargo, el análisis de correspondencia mostró que los mayores desempeños no necesariamente se alinean con un mayor volumen de capital científico. Nuestros hallazgos demuestran el potencial del capital científico para explicar la influencia de las desigualdades en el desempeño en ciencias, aunque el concepto presenta ciertas inconsistencias con la teoría de los capitales de Bourdieu.

PALABRAS CLAVE: Clase social. Desempeño. ENEM. Factores socioeconómicos. Capital científico.

Introduction

Understanding how young people relate to science and the motivations that lead them to choose a science-related career is a challenge for researchers in the field of Science Education. At a global level, there is a concern with the low interest of young people in studying Science, Technology, Engineering and Mathematics (STEM), and, in the future, in working with science. This concern prompted the British government to initiate the ASPIRE project, a five-year project funded by the UK's Economic and Social Research Council (ESRC). This project sought to investigate factors related to the low involvement of young people between 10 and 14 years old, with the STEM study (Archer; Osborne, *et al*., 2013). These studies pointed out a strong influence of the family on the students' motivations, and, in the case of pursuing a science-related career, the determining factor was the family's amount of science capital.

In Brazil, a large part of science-related professions requires higher education. To access public higher education, however, it is necessary to pass entrance exam, the National High School Exam (shortened as ENEM) the most comprehensive in the country. According to the Brazilian government, with more than 7 million subscribers, ENEM is the second largest exam used for university admittance in the world, following China's GAOKAO exam, which, in 2015, received 9 million registrants (MINISTÉRIO DA EDUCAÇÃO, 2015). However, studies that investigate the relationship between scientific aspirations and performance on ENEM, or that use science capital to explain such a relationship, are non-existent.

The term science capital, introduced by Louise Archer and colleagues (2012), using Pierre Bourdieu's theoretical lens, describes how family habitus shapes children's involvement and identification with science. It highlights how family resources, particularly their understanding of and relationship to science, influence students' education and career choices beyond compulsory schooling (KING *et al*., 2015, p. 2989). Research shows that science capital is unequally distributed across social classes, with middle-class students possessing high science capital, while working-class students often view science as an unfamiliar path (Archer *et al*., 2012). Rooted in sociology, science capital is tied to efforts to democratize access to science and related careers (Archer; Dewitt; Osborne, 2015; Dewitt; Nomikou; Godec, 2019; Moote *et al*., 2019; Moote *et al*., 2020; Nomikou; ARCHER; King, 2017; Wong, 2016).

Building on studies about the benefits of engaging young students with science, this article analyzes the profitability of science capital within the school market. According to Bourdieu (1986,

p. 241), accumulated forms of capital possess "a potential capacity to produce profits and to reproduce in an identical or expanded form," resulting in various advantages. This study examines whether high levels of science capital translate into tangible benefits within the school environment, hypothesizing that its profitability (measured by its capacity for conversion) may manifest as improved performance in higher education entrance exams.

This study examines the association between student performance on ENEM, and practices indicative of a high level of science capital, contributing to the discussion of the science capital model proposed by Archer *et al*. (2015) in the Brazilian context. This focus is justified for two reasons: first, the model has been criticized for its overlap with Bourdieu's concept of cultural capital (Jensen; Wright, 2015); second, our dataset includes nearly 400,000 students, significantly exceeding the 3,500 participants in Archer *et al.'s* (2015) study.

Genesis and development of the concept of scientific capital

Archer, DeWitt, et al. (2013, p. 6) defined science capital first as "[...] the material and cultural science-related resources that a family may be able to draw on, such as science-related qualifications, knowledge, understanding ('scientific literacy'), and social contacts and [...]". The authors then complement this definition by stating that this capital "[…] interacts with family habitus to shape the likelihood of children developing science aspirations".

However, in a recurrent way, Archer and colleagues propose that science capital:

> […] is not a separate "type" of capital but rather a conceptual device for collating various types of economic, social, and cultural capital that specifically relate to science — notably those which have the potential to generate use or exchange value for individuals or groups to support and enhance their attainment, engagement and/or participation in science (Archer; Dewitt; Wills, 2014, p. 5).

Archer *et al*. (2015) define science capital as a combination of three interconnected elements: a scientific form of cultural capital, science-related behaviors and practices, and science-related social capital. The scientific form of cultural capital encompasses scientific literacy and dispositions, reflecting the transferability of scientific qualifications and culturally valued knowledge (Archer et al., 2015). Science-related behaviors and practices refer to the consumption of science through media, and informal learning environments (Archer *et al*., 2015). Social capital related to science involves the degree of socialization and habits of discussing science (Archer et al., 2015). King *et al*. (2015) later clarified these dimensions, distinguishing them more explicitly.

To quantify the students' science capital, Archer et al. (2015) begins the analysis with the Principal Component Analysis (PCA). The result of the PCA revealed nine components, which were understood as parts or characteristics of science capital. Based on previous studies, the authors considered the component "Future science job affinity (aspirations)" as the main component, and also as a dependent variable for a logistic regression that allowed for measuring science capital as high, medium, or low (Archer *et al*., 2015).

Returning to Bourdieu's theory, Dewitt and Archer (2017) problematized the predominance of the value of the arts in the original proposal of cultural capital, to reaffirm the need for a tool capable of evidencing the individual's resources and scientific dispositions. In essence, science capital is a conceptual tool that captures individual ownership of resources and dispositions associated with science, (Nomikou; Archer; King, 2017) and these resources and dispositions "[...] are duly recognized by others in ways that enables the individual to 'get on' in life" (King; Nomikou, 2018, p. 89-90).

The concept of capital for Bourdieu and its relationship with science capital

Throughout the development of his entire theory, when studying different fields of society, Bourdieu recognized the presence of hierarchies of power that were not limited to the economic dimension. They could only be explained by considering aspects such as the unequal distribution of cultural, social, economic, and symbolic aspects. By studying particular fields, he also admitted the existence of specific capitals for each of them. For example, the scientific field – of production and distribution of scientific knowledge – hierarchically distributes the agents that have greater, and lesser amount of scientific capital.

Outside the context of the scientific field and concerned with school performance and professional guidance of students, Louise Archer proposed the creation of a new form of capital: science capital. According to the author, this form of capital could not be subsumed into those already present in Bourdieusian theory, although it admits greater proximity to the notion of cultural capital (Archer *et al*., 2015; Dewitt; Archer, 2017; Moote *et al*., 2019). However, Jensen and Wright (2015) criticized this notion of independence, pointing to an overlap between science capital and cultural capital.

To explore and test this concept theoretically and empirically, it is essential to revisit the definition and fundamental properties of capital, particularly cultural capital, which closely relates to science capital, within Bourdieusian theory. As a relational and dialectical framework guided by empirical insights, Bourdieu's work does not offer a fixed definition, instead refining the concept across various contexts. Cultural capital, central to understanding educational inequalities, was developed in works such as *The Inheritors* and *Reproduction in Education, Society and Culture* (Bourdieu, 1979, 1990).

According to Nogueira (2017), capital refers to a form of wealth or resource that underpins the division of society into classes and defines an individual's social position. It involves the 'production, distribution, and consumption of (a specific type of) goods capable of paying dividends, that is, providing symbolic profits' (Nogueira, 2017, p. 104). Bourdieusian theory identifies three fundamental properties of capital. First, it represents a form of power or wealth, whose value arises from symbolic struggles within each social, historical, and contextual field. Second, it can be accumulated, transmitted, and converted into material or symbolic goods, benefiting those with high amounts and allowing conversion into other forms of capital. Third, it is intrinsically tied to the dominant classes, which define the legitimate forms and reference amounts of capital, heavily influenced by agents' family backgrounds.

Therefore, bearing in mind these fundamentals of the Bourdieusian theory, we ask ourselves about three central points: 1) Does science capital meet the three fundamental properties of capital?; 2) If it is considered a form of capital, how does it differ from cultural capital?; 3) As for its distinction from cultural capital, does the empirical analysis confirm the profitability of science capital?

Methods

We used statistical analysis (mean, regression models, and correspondence analysis) to analyze the microdata of ENEM 2009 and understand which factors related to science influence the performance in the natural sciences test. Our database is made up of two parts, collected at different times: 1) the socioeconomic questionnaire, a questionnaire composed of categorical tests and completed at the time of registration for ENEM; and 2) the score in the natural science test, a test composed of 45 multiple-choice questions (from A to E), which uses the Item Response Theory for correction. Through these data, we empirically test the existence and profitability of science capital, complementing theoretical studies in the literature with an analysis involving approximately 400 thousand students.

However, we acknowledge that the database used is generic, and was originally designed for objectives different from those of this study. Additionally, the limited number of science-related questions in the socioeconomic questionnaire may pose potential limitations to our results.

The National High School Exam (ENEM)

In the Brazilian context, since 2009, student access to public universities has been mostly based on the result of an annual entrance exam, the ENEM. The average performance of students in four objective tests – Natural Sciences (chemistry, physics, and biology), Human Sciences, Languages, and Mathematics – and in a short essay is the criterion for this selection. Considering the significant number of candidates who have taken the exam since then – an average of 5 million people – ENEM has become an important source of data for research in the educational field. This database is publicly available on the website of the Institute for Educational Studies and Research "Anísio Teixeira" (INEP) (www.gov.br/inep) through the path: access to information > open data > microdata > ENEM.

Due to ENEM relevance at the national level, since its creation, many studies have analyzed data from ENEM to investigate educational inequalities in the Brazilian population (Travitzki; Calero; Boto, 2014; Travitzki; Ferrão; Couto, 2016; Rocha; Nascimento, 2019). The ENEM database was also used by science teaching research to analyze, for example, difficulties in learning physical concepts (Barroso; Rubini; Silva, 2018), and the influence of socioeconomic status on performance in natural science items (Kleinke, 2017; Nascimento; Cavalcanti; Ostermann, 2018).

Student sample

We selected the 2.4 million candidates who took the exam in the year 2009, in which the socioeconomic questionnaire had the highest number of items, to capture the greatest breadth of information about their perceptions and dispositions.

We applied two filters to the data. First, we selected candidates who attended the final year of high school, ensuring the inclusion of first-time applicants for higher education. Second, we excluded candidates who did not answer any questions in the socioeconomic questionnaire. After applying these filters, the sample comprised approximately 350,000 students, which is sufficient for any type of statistical analysis. Table 1 presents the profile of the candidates in the sample.

TABLE 1. Profile of the sample of candidates that is part of this study.

Items	Responses distribution							
Gender	Uninformed	Male	Female					
	0,14%	37,80%	62,06%					
Ethnicity race	Uninformed	Indigenous	Yellow	Black	White			
	0,56%	0,53%	2,96%	44,72%	51,23%			
Mother instruction	Uneducated	Incomplete elementary school	Incomplete high school	Complete high school	Incomplete graduation	Complete graduation	Post-graduation	
	2,90%	35,77%	7,18%	26,84%	5,06%	14,39%	7,86%	
Father instruction	Uneducated	Incomplete elementary school	Incomplete high school	Complete high school	Incomplete graduation	Complete graduation	Post-graduation	
	4,57%	41,95%	7,10%	24,72%	4,96%	11,84%	4,88%	
Family income/USD per month	Until USD100	Between USD100 and USD200	Between USD200 and USD500	Between USD500 and USD1000	Between USD1000 and USD3500	Between USD3500 and USD6000	More than USD6000	Without income
	13,93%	29,79%	32,11%	12,74%	6,98%	1,28%	0,48%	1,18%
School administration	Public-school (state)	Public-school (federal)	Public-school (municipal)	Private-school				
	66,81%	2,13%	1,46%	29,61%				

Source: prepared by the authors

There is a predominance of female candidates (62.06%), self-declared whites (51.23%), and blacks (44.72%), with the majority of relatives with secondary education at most (~ 80%), with a monthly family income of less than $500, and from state public schools (66.81%). These data point to socioeconomic conditions that are not socially favored, considering the Brazilian reality or, in Bourdieusian terms, a family origin and primary socialization marked by low amounts of cultural and economic capital.

Questionnaire

The socioeconomic questionnaire that the students answered at the registration time for ENEM 2009 had more than 200 items, that gathered information about their life, school, and work. In addition to the traditional questions that assess the amount of economic and cultural capital of individuals, in this edition of ENEM, we can note some items that addressed candidates' perceptions, interests and attitudes in relation to the most diverse subjects.

In this sense, we could identify those items which converged on the factors extracted by Archer et al. (2015) in their ASPIRES project questionnaire, linked with high science capital. This strategy is similar to that carried out by Du & Wong (2019) with the PISA socioeconomic questionnaire. The details of the dimensions of science capital presented by King *et al*. (2015) also helped in this approach. We identified a total of 10 questions (all in the section "about the school") that collected data on the student's relationship with science. Table 2 shows these ten items from the ENEM questionnaire, that were associated with six of the nine components used by Archer *et al*. (2015) in the development and analysis of science capital.

TABLE 2. Items from ENEM questionnaire and factors obtained by Archer *et al*. (2015) to which they relate.

science capital forms	Items	Factors obtained by Archer *et al.* (2015)
Science-related cultural capital	1 - Which career would you like to pursue? (STEM related career, Humanities related career, Arts related career, Health or biology related career, Teaching related career, I didn't choose yet, I'll not follow any career)	Future science job affinity (aspirations)
Science-related forms of social capital	2 - How much did your parents help you to choose your career? (They didn't help, helped a little, or helped a lot) 3 - How much did your school help you to choose your career? (It didn't help, helped a little, or helped a lot) 4 - How much did your friends help you to choose your career (They didn't help, helped a little, or helped a lot)	Parental attitudes and practices (including attitudes to science) Science teachers and lessons
Science-related behaviors and practices	5 - How often you read magazines related to STEM? (very often, sometimes, or never) 6 - How often you read biographies or scientific books? (very often, sometimes, or never)	Everyday science (media) engagement
	7 - How do you assess the conditions of your school's laboratories? (insufficient to regular, regular to good, or good to excellent) 8 - Does your school promotes a science fair? (Yes or no)	Science teachers and lessons
	9 - How interested are you in environmental issues? (very interested, little interested, or not interested) 10 - How interested are you in sexuality issues (STDs, pregnancy...)? (very interested, little interested, or not interested)	Valuing science and scientists

Source: prepared by the authors

We associated the first item (Which career would you like to pursue?) with aspirations to pursue a science-related career, reflecting awareness of science's value in the labor market, a form of science-related cultural capital (King *et al.*, 2015). Items two, three, and four mapped the influence of relatives, friends, and school on choosing a STEM career. These were linked to two factors - family and school - both associated with science-related social capital (King *et al*., 2015). Items five and six, addressing the frequency of reading scientific books and magazines, reflect practices similar to engaging with science (Archer *et al*., 2015). Items seven and eight assessed whether the school provided science-related learning spaces, such as fairs and laboratories. The final two items measured students' interest in science topics, including environmental and health issues. Overall, the last six items relate to the consumption of science through extracurricular activities, aligning with science-related behaviors and practices (Archer *et al*., 2015; King *et al*., 2015).

Analytical approaches

We carried out an inspection on the distribution of the average score in ENEM's Natural Sciences test for each of the categories of responses present in the ten items described in Table 2. Considering that the aspirations to pursue a science-related career may indicate a higher level of science capital (Archer *et al*., 2015; Bøe; Henriksen, 2015; Regan; Dewitt, 2015; Moote *et al*, 2019), the analysis of the performance of these students reveals potential to investigate the profitability of science capital itself. The examination of the other seven items followed the same analytical procedure.

Given the criticism by Jensen and Wright (2015) regarding the overlap between science capital and cultural capital in Archer *et al.'s* (2015) work, we analyzed the performance of candidates with high science capital across different social classes, defined by economic and cultural capital. This analysis aimed to demonstrate differences in performance attributable to science capital, when controlling for cultural capital. To ensure the validity of the results, additional statistical tools, including analyses of variance, multivariate regressions, and correspondence analyses, were employed.

Results and discussion

We structure the results and discussion by first presenting the exploratory analyses, followed by the inferential analyses. While some results have been published in the Moris (2021) master's dissertation, the discussion presented here is original and engages with international literature on science capital.

Exploratory analysis

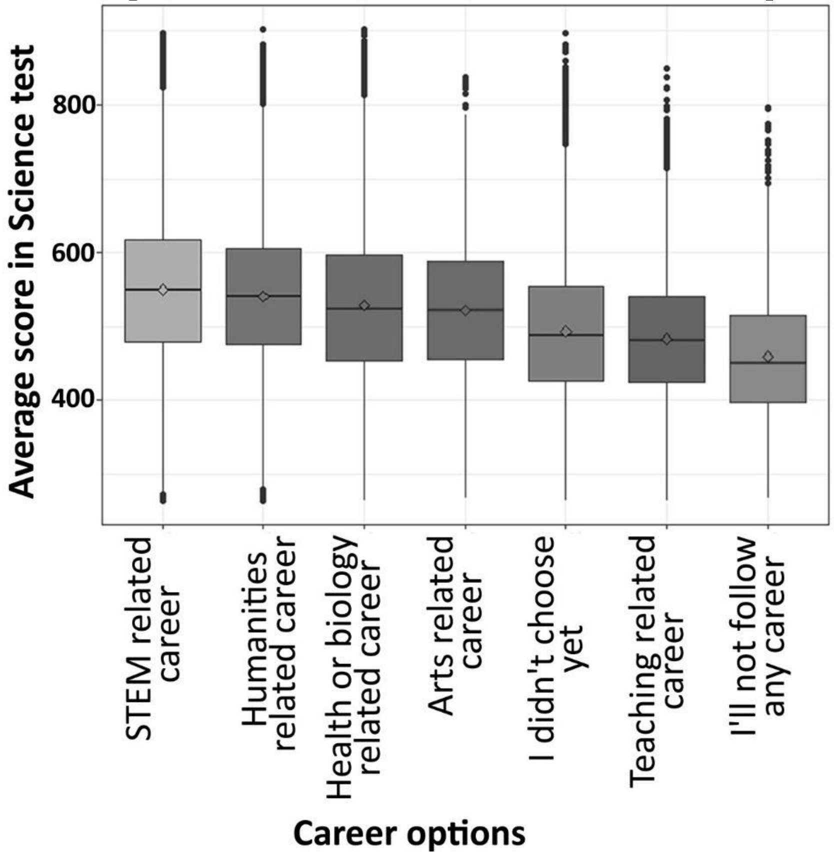
In this first dimension of analysis, the average number of correct answers in the ENEM's Natural Sciences test for each of the categories of responses present in the ten items of Table 2 was investigated. To structure the text, the following subsections elaborate on how these items respond to each of the three aspects of science capital.

Science-related cultural capital

To examine science-related cultural capital, we compared the average science scores with career choices and socioeconomic status (SES). To delve deeper into the analysis and estimate the influence of each factor on student performance, we conducted an Analysis of Variance (ANOVA), to identify statistically significant differences in Natural Sciences exam scores. The ANOVA results showed a significant difference ($p < 0.05$) in scores between students aiming for STEM careers, and those pursuing other careers. All analyses in this section relied on ANOVA to confirm statistically significant differences across response groups, with all results showing $p < 0.05$.

The ENEM questionnaire item that asks which career the candidate would like to pursue in the future has seven answer options, which are presented on the horizontal axis of the graph in Figure 1. The scores of the ENEM test can take values from 0 to 1000, depending on the year of application of the test. This is because the exam is corrected based on the Item Response Theory (IRT), and not by the Classical Test Theory (CTT) (Embretson; Reise, 2013).

FIGURE 1: Average score in the natural sciences test in function of professional interest.



Source: prepared by the authors

Candidates who claim to have an intention to pursue a career linked to STEM obtain the highest average in the Natural Sciences exam (549.62 points). It is noteworthy that the three largest averages are related, in some way, to scientific areas. The second highest average was achieved by those students who indicated interest in following in the humanities (540.01 points), and the third highest average for individuals interested in working in the field of health sciences (528.04 points).

However, our results pointed out that those students who achieved the best grades in the ENEM Natural Sciences intend to pursue a career associated with STEM. Considering that the intention to pursue science-related careers is one of the elements that make up science capital, our results showed that science capital was related to better performances, which imply greater chances of access to education higher. Moote *et al*. (2019) highlighted the link between high science capital and the desire for a STEM degree, with Physics being the most desired course. Essex and Haxton (2018) demonstrated that students with high science capital are more engaged in STEM activities and possess greater scientific knowledge. This preliminary analysis identifies two dimensions of science capital:

holding scientific knowledge (science literacy) and recognizing science's value in the labor market (Archer *et al*., 2015; King *et al*., 2015; Dewitt, Archer, & Mau, 2016), consistent with Bourdieu's notion of capital.

Figure 1 shows that students who achieved the highest scores on the ENEM Natural Sciences test were those intending to pursue STEM-related careers. Research on large-scale exams consistently identifies socioeconomic status (SES) as the primary factor influencing final results (SIRIN, 2005). To ensure the result in Figure 1 is not skewed by SES, the same analysis was conducted for students with similar SES. SES was determined through cluster analysis, grouping students based on parental education levels and average family income. Students were classified into seven clusters, ranging from very low to very high SES. Table 3 presents the relationship between test scores, SES, and career choices.

TABLE 3. Average grade in the Natural Sciences test according to career choice and socioeconomic status.

Socioeconomic status	STEM related career	Humanities related career	Health or biology related career	Arts related career	Teaching related career	I'll not follow any career	I didn't choose yet
Very Low	**476.55**	468.22	458.45	448.83	450.91	416.39	444.63
Low	**507.35**	496.89	482.09	479.12	475.49	449.83	470.10
Low-middle	**521.27**	511.21	500.10	498.27	484.67	450.28	481.33
Middle	**534.02**	522.03	512.07	508.34	490.34	460.14	488.78
Upper-middle	**562.47**	547.54	545.25	537.24	514.13	487.03	519.20
High	**604.76**	585.17	592.26	573.75	543.27	541.30	565.54
Very high	**654.46**	624.89	645.62	616.57	604.95	568.67	619.65
Number of respondents	100394	67810	89835	11661	16017	1312	60471

Source: prepared by the authors.

This analysis revealed that candidates who chose STEM careers scored higher, compared to students from the same SES who made other career choices. In other words, regardless of the SES, candidates with an interest in pursuing a career linked to STEM obtained the best performance in the test, on average. This result suggests that the willingness to pursue a science-related career is a distinguishing factor for students with the same SES. It is worth noting that this factor does not overcome the influence of the SES itself, that is, the differences between social classes remain demarcated.

Considering the relationship between social class and the possession of greater or lesser amounts of capital, foreseen in the Bourdieusian theory, Table 3 allows us to verify that the distribution of performance in relation to STEM careers increases, proportionally, with the improvement of SES. For Bourdieu, economic, social, cultural, and symbolic capitals are identified with the dominant classes, which determine the form and amount of reference of what will be considered as legitimate capital. Bourdieu (1984) identifies that the middle or lower classes tend to imitate the capitals of the elites, even though they have access only to a lightened version of these capitals. The proportional increase in performance with the SES for candidates who wanted STEM careers allowed us to infer the association between science capital and social class. It suggests that subjects of high social class tend to identify with science, aim for science-related careers and hold a greater amount of science capital (Archer *et al*., 2012; Moote et al., 2019; Du; Wong, 2019; COOPER; Berry, 2020).

In addition to class being a primary factor in explaining performance, the analysis also revealed that candidates pursuing STEM-related careers scored higher than peers from the same SES who chose other careers. This suggests that interest in science-related careers—a component of science capital—acts as a form of symbolic profit, contributing to better performance and increased access to higher education. According to Bourdieusian theory, agents within the same class share similar cultural capital, making science capital a key factor in explaining superior performance. This aligns with findings by DeWitt *et al*. (2016), which showed that science capital was more effective than cultural capital in predicting science-related aspirations and career choices.

Science-related forms of social capital

The ENEM questionnaire infers the influence of help from parents, friends, and school in choosing a career. For each of these groups the student assesses the impact of this influence from three levels of help: didn't help, helped a little and helped a lot. Table 4 shows the distribution of responses for each of the profession categories described in the previous section. In addition, the average score in the natural sciences test is also presented.

TABLE 4. Influence of help from parents, friends, and school in candidates' career choice.

		Parents		Friends		School	
	How much they/it did help?	%	Average score	%	Average score	%	Average score
Arts related career	A lot	31,34%	514,74	27,28%	523,38	17,37%	512,14
	A little	38,04%	526,75	41,40%	523,46	38,41%	523,60
	Didn't help	30,62%	523,42	31,32%	518,75	44,21%	524,40
Health or biology related career	A lot	41,42%	525,01	17,98%	522,36	22,39%	538,99
	A little	36,81%	535,82	43,21%	531,02	42,77%	531,66
	Didn't help	21,77%	521,97	38,81%	528,10	34,84%	517,38
Humanities related career	A lot	37,94%	540,49	18,52%	540,08	22,68%	**550,04**
	A little	38,53%	544,67	44,98%	544,07	43,53%	542,97
	Didn't help	23,53%	533,03	36,50%	535,88	33,78%	530,45
STEM related career	A lot	37,11%	542,26	17,64%	548,83	24,54%	**566,07**
	A little	40,47%	558,08	45,43%	553,35	43,44%	549,64
	Didn't help	22,42%	547,89	36,93%	546,23	32,02%	537,94
Teaching related career	A lot	43,10%	471,99	20,02%	477,02	41,70%	486,27
	A little	32,42%	492,17	42,90%	483,83	37,88%	482,35
	Didn't help	24,49%	491,84	37,08%	486,32	20,42%	479,44

Source: prepared by the authors

The role of parents in their children's career choice suggests that they exert significant influence over it, except for those who choose to pursue careers linked to the arts. This statement is based on the fact that, with three possible levels of choice, if candidates were evenly distributed, 33% would be observed for each level of influence. Thus, variations above or below this value serve as an indicator of the impact of this influence. Looking at the performance in the test among this parental influence group, the best performances are related to an intermediate level of influence, namely, across all the professions.

In the case of the help from friends and school in the choice of career, either a little (~ 40%) or no help (~ 40%) is observed in this decision. The exception is found in the case of candidates who choose careers linked to education, confirming the influence of the school. Regarding school influence in choosing a career, candidates who opted for careers linked to STEM and human sciences or who stated that the school had influenced over this decision had a test average above the value indicated in the previous section (549.63 for STEM and 540.01 for humanities).

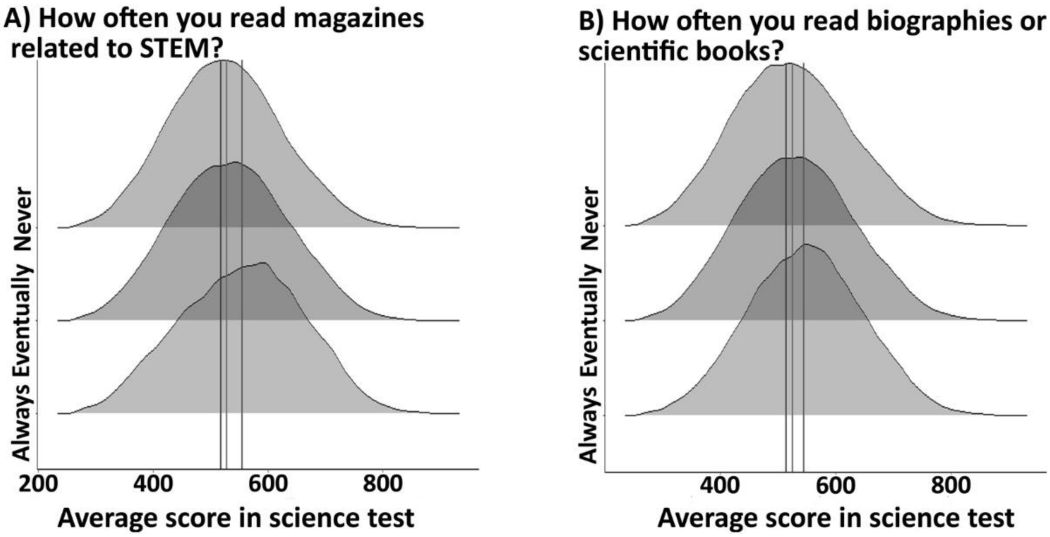
This data underscores the primacy of the family in transmitting any form of capital. The family has been identified as a key factor in determining the amount of science capital, with middle-class families perceiving science-related careers as a natural path, whereas such choices are often unthinkable for the working class (Archer *et al*., 2012; Dewitt *et al*., 2016; Archer et al., 2020).

Having high science capital is directly linked to having a family member with a science-related career, receiving family encouragement to participate in scientific activities, and the family's ownership and transmission of that capital (Archer; Dewitt; Osborne, 2015; Dewitt; Archer, 2017; Mujtaba *et al*., 2018; DeWitt & Archer, 2015; Archer *et al*., 2020). This helps explain why such influence shapes different career choices, linking them to general forms of cultural capital, while also highlighting the specificity of STEM and science capital.

Science-related behaviors and practices

We used two items of the questionnaire that inquire about the frequency with which candidates read (i) books of science dissemination and (ii) non-fiction books, to investigate reading habits. Candidates could mark the box for "always carry out this type of reading", "eventually" or "never". Figure 2 shows the distribution of candidates for each frequency option, depending on performance. The vertical lines indicate the test average for each group.

FIGURE 2: Distribution of candidates and average in the natural sciences test in function of the frequency of reading.

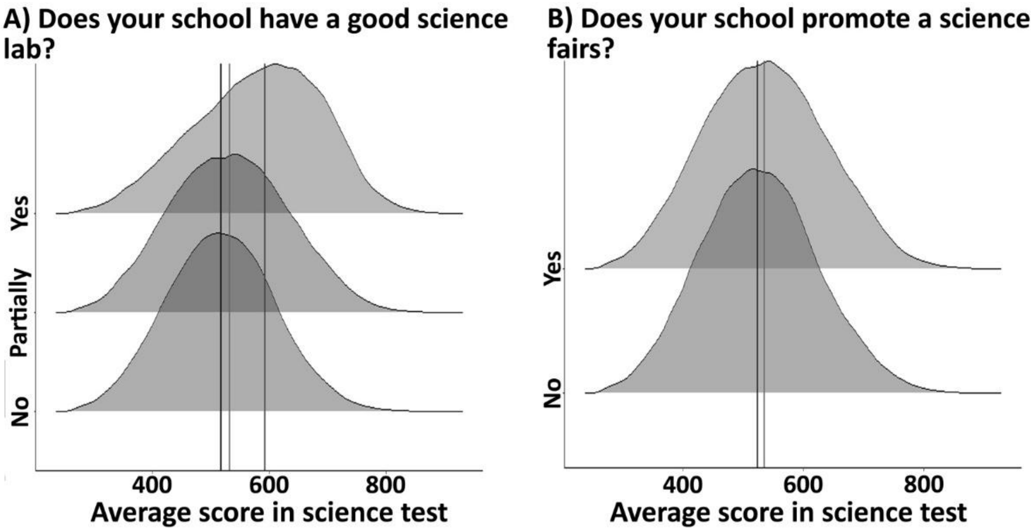


Source: prepared by the authors

The averages associated with STEM-related readings (Always 555; Eventually 528; Never 518) and scientific biographies or books (Always 545; Eventually 525; Never 514) are higher, the higher the frequency of reading, especially in the case of books of scientific dissemination. The association between higher reading frequency and better performance on the test allows us to recognize the relevance of this factor as a component of science capital.

The role of the school in engaging candidates with questions related to science can be analyzed from two items in the socioeconomic questionnaire. One item gathered information on the conditions of the school's science laboratory, and the other questioned whether the school held scientific fairs. Regarding the laboratories, students could check whether the school had laboratories in regular, good, or excellent condition. Regarding the holding of science fairs at school, the answer was only “yes” or “no”. The comparison of these responses with the performance of these groups in the test is shown in Figure 3.

FIGURE 3: Distribution of candidates and average in the natural sciences test in function of the characteristics of the candidate's schools.



Source: prepared by the authors

Figure 3 shows that good conditions of a science laboratory are reflected in better performance in the science test (581 points), in comparison to results from students in other groups (533 and 517 points). Regarding the item that asks whether the candidate's school holds scientific fairs, we observed that the students who answered “yes” to the questionnaire scored slightly above average in the test, compared to those who answered “no”.

The fact that a school has laboratories in good condition is an indication that this institution has good economic conditions, which can be associated with high economic capital. However, the destination of these financial resources for the construction and maintenance of science laboratories reveals an institutional interest in scientific areas. Candidates who had the chance to study in these schools lived with this valorization of science, which may represent greater science capital compared to students who did not have this privilege, as the investment in laboratories and consequent use can stimulate a perception of the symbolic value and market share of science. The fact that the performance of these students is higher than that of candidates who did not study in schools with good science laboratories supports the argument that there is some kind of profitability of the concept of science capital proposed by Archer *et al*. (2015).

The interest of students in science-related topics was measured by the following items: How interested are you in environmental issues? How interested are you in sexuality issues (STDs, pregnancy...)? The response options for both items were high interest, low interest, or no interest. In these items, there was no association between the candidates' performance in the test and a greater interest in the themes, diverging from what was observed in the previous items. In summary, in the two items that provide information on the interest in themes related to science, a greater interest does not relate to a better performance in the natural sciences test.

Based on the results, we can address our first two questions: the empirical necessity of science capital was demonstrated in explaining test performance, as it showed a clear relationship with class and family; and the results suggest distinctions from cultural capital, as science capital appears to explain behaviors that neither cultural capital nor class alone could fully account for. We now proceed to analyze the components of science capital, having already established the relevance of interest in pursuing STEM careers.

Deepening the analysis

Eight out of the ten items initially selected as possible indicators of science capital showed an association with the performance of the Natural Sciences test and deserve a more detailed investigation. We changed the names of some items to facilitate the presentation of the tables, and focus on the main information that the item measures. So, "Which career would you like to pursue?" It became "Work in science", and the different sources of help were understood as forms of influence, and renamed "Parents Influence", "School Influence", and "Friends Influence".

In order to quantify the association of each of these items with the performance in the test, we built different multivariate linear regression models, in which the students' performance was taken as a dependent variable, and the indicator items of science capital as independent variables. As previously discussed, socioeconomic status (SES) is one of the factors that most explains students' academic success (SIRIN, 2005). Therefore, the first multivariate linear regression model had only SES as a dependent variable. Sequentially, we incorporated each of the eight items into the initial model to infer the factors influencing candidates' performance in the Natural Sciences exam. Then, the final model was built to find out which items contribute the most to the students' average grade in the exam. Table 5 shows the five partial models, and the final model of the regressions performed.

TABLE 5. Linear regression models.

	Model 1	Model 2	Model 3	Model 4	Model 5	Final Model
Constant =	405.79	370.33	405.53	371.13	389.71	296.53
SES	87.38	83.66	89.14	87.15	82.58	82.13
Work in science		14.72				23.88
Parents Influence			12.93			13.13
School Influence			-12.28			-9.93
Friends Influence			-0.19			
Scientific magazine reading				5.50		4.22
Nonfiction books reading				12.14		10.79
School's lab condition					11.99	10.97
Science Fair					0.16	
Adj. R^2 =	0.23	0.26	0.24	0.24	0.24	0.27

Source: prepared by the authors

Model 1 reveled the value of the SES coefficient is 87.38, and that of R^2 is 0.23. This indicates that an increase of one unit in the SES variable results, on average, in an increase of more than eighty points in the test average; and that the SES by itself explains approximately 23 percent of the test result.

Model 2 incorporated career choice as a dichotomous categorical variable, separating candidates into two groups: those intending to pursue a science-related career, and those who do not. This recoding resulted in a coefficient of 14.72 for the item, and an R^2 of 0.26 for the model. This indicates that students intending to pursue a science-related career score, on average, nearly 15 points higher than those considering other professions. Notably, this model achieved the highest R^2 value, apart from the final model's explanatory factor.

In model 3, we added to the SES the items that measure the influence of parents, school, and friends in the career choice. We observed that only the influence of parents contributes positively to the test average. The R^2 of this model indicates that these combined variables explain 24 percent of the performance.

Model 4 adds to the SES the items about the frequency of reading scientific magazines and non-fiction books. Both types of reading return positive coefficients, however books have a greater impact. The R^2 for these items combined with the SES is the same as for model 3. Similarly, model 5 - which adds to the SES the items about the conditions of the school science laboratory and science fair - does not increase the explanatory factor in relation to the previous model, although both coefficients are positive.

Finally, we constructed the final model using the stepwise technique, which produced an R^2 of 0.27, representing an improvement over Model 2. This R^2 value is close to that observed in similar studies (Américo; Lacruz, 2017). This final model included the items: SES, choice of profession, influence of parents, influence of school, reading of scientific dissemination magazines, reading of scientific books, and conditions of the school laboratory. The other items were excluded from the final model. The exclusion of factors about influence of friends, and science fairs may point to a weakness in the science capital theoretical framework, since it is not clear whether the authors 1) identified the factors from the empirical analysis of the data; 2) built this data theoretically; 3) addressed a specific characteristic of Brazil. For instance, regarding science fairs, they are not a traditional practice in Brazil, are typically limited to certain schools, and rarely engage the entire school community.

The associated coefficient of “Work in science” (28.88) is the highest in the final model, excluding the SES (82.13). This high coefficient of “Work in science” indicates that the choice of profession emerges as the most explanatory variable of the students' performance in the test. The Regression Analysis also allowed us to verify the relationship of the items in the final model with the performance in natural sciences. Thus, we understand these six items as indicators of science capital.

To confirm the connection between these items and factors related to the concept of science capital (Archer *et al.*, 2015; Jones *et al.*, 2020; King *et al.*, 2015), we conducted a Factor Analysis (FA). FA addresses the challenge of examining correlations among a large number of variables, such as questionnaire items, by estimating a set of common latent dimensions, referred to as factors (Hair *et al.*, 2009). The choice of method for FA depends primarily on the nature of the variables (Edelen; Reeve, 2007). For this analysis, we employed the Graded Response Model (Samejima, 1968), which requires items to have ordered response categories, regardless of the number of categories per item (Muraki, 1990; Takane; De Leeuw, 1987; Woods-Groves; Eaves; Williams, 2011).

Therefore, we keep the item "Work in science" as a dichotomous categorical item, considering "1" for the candidate who chose to pursue a scientific career and "0" for those who chose another profession. The six items were grouped into four factors. The FA result is shown in Table 6. For each of the 4 factors, we calculate the value of Cronbach's alpha, a measure of the factor's reliability (Taber, 2018): F1, α = 0.74; F2, α = 0.77; F3, α = 69, and F4, α = 70.

TABLE 6. Factor loads of the six science capital indicator items. The largest charges for each item are highlighted in bold.

	F1	F2	F3	F4
Scientific magazine reading	0.01	**0.63**	0.01	0.01
Nonfiction books reading	-0.01	**0.67**	-0.01	-0.04
Science Lab	0.00	0.00	0.00	**0.64**
Work in science	0.00	0.00	**0.70**	0.00
Parents Influence	**0.52**	0.01	0.12	0.20
School Influence	**0.79**	0.00	0.09	0.00

Source: prepared by the authors

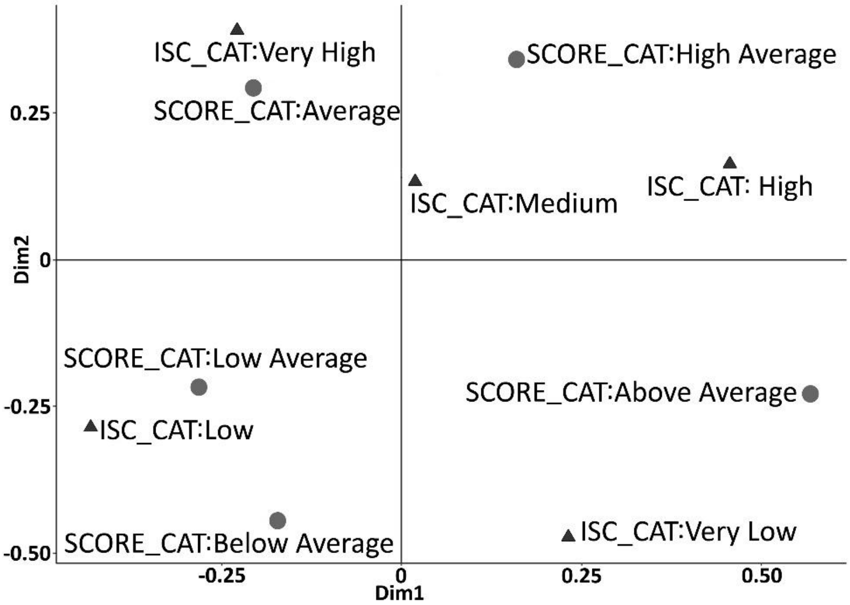
It is noted that the six items are very well grouped into four distinct factors. In the first factor, the most important items deal with the influence of parents and the school in the career choice, with factorial loads of 0.52 and 0.79, respectively. The second factor grouped the reading frequency items, both with factor loads greater than 0.6. The preference for pursuing a science-related career appears as the only relevant item for factor 3, with a factor load of 0.7. Finally, the item regarding the quality of the school science laboratory appears alone in factor 4, with 0.64 factor load.

The factor analysis confirmed the key elements of Archer's model, with F1 associated with science social capital, F2 with media consumption, F3 with the cultural aspect and labor market, and F4 with the cultural and social value of the laboratory. Our factors also aligned closely with those identified by Jones *et al.* (2020), which categorized F1 as identification with science, F2 as engagement in extracurricular scientific activities, F3 as the perception of science's usefulness, and F4 as family attitudes. Thus, our initial grouping demonstrated consistency with the frameworks of Archer *et al.* (2015) and King *et al.* (2015), reinforcing the reliability of our associations and supporting our analyses and interpretations.

From the definition of these four factors, we could build a science capital index (SCI). This index was estimated from a multivariate FA (four dimensions), considering the interrelationship between the factors. With this, it was possible to calculate the science capital scores for each individual. The analysis was conducted across four dimensions, resulting in each student receiving four distinct scores. Subsequently, students were grouped into five SCI clusters: very high, high, medium, low, and very low. This clustering was performed using the k-means method, aiming to minimize within-cluster variances while maximizing variance among clusters (Macqueen, 1967). In this case, we divide the students into five groups.

After the construction of the five SCI clusters, we performed a Correspondence Analysis (CA), relating each cluster to a score on the natural science test. The objective of CA is to visualize on a map of reduced dimensions the association between categorical variables (Greenacre, 2017). As the CA works only categorical variables, we again use clustering to group students into five performance groups: above average (645 - 903.2), high average (558.7 - 644.9), average (483.6 - 558.6), low average (404.8 - 483.5), and below average (263.3 - 404.7). Greenacre (2017, p. 12-13) explains that "Two points that are close to each other will have similar results in the examination, just like two neighboring towns having a small distance between them". The proximity of the SCI to performance groups of SCI indicates the way to evaluate the profitability of science capital. The result of this analysis is shown in Figure 4.

FIGURE 4: Correspondence Analysis with the Science Capital Index (ISC) (triangles) and Test Performance variables (SCORE_CAT) (circles).



Source: prepared by the authors

Figure 4 shows the distance between high and low levels of SCI and performance. All other variables seem to follow the same pattern, except for the highest performance category (an outlier):

as SCI increases, performance improves. The lowest SCI is near to the two lowest performances groups. On the other hand, the highest SCI is close to high average and average performances. This association between the SCI and student performance reveals the existence of a kind of science capital profitability.

The large gap between the best performance group and the highest SCI may indicate that science capital was not able to predict the best performance as SES was. This limitation can lead to interpreting science capital as a social strategy and not a capital, in Bourdian theory, as we argued in previous works (Moris, 2021; Moris; Massi; Nascimento, 2022).

Final considerations

We conducted a study with more than 300 thousand Brazilian students, involving the second largest exam for access to higher education in the world, aiming at testing theoretically and empirically the notion of science capital proposed by Archer et al. (2015). The concept has been recognized as a key explanation and predictor of interest in science, proving fundamental in STEM studies, and of global significance for research in Science Education.

The analysis of test performance in relation to interest in STEM careers and students' social class of origin confirms that social class remains the primary determinant of performance. However, the distribution of science capital within the same class varies, contributing to the explanation of performance differences. Regarding the components of cultural capital, the factors derived from factor analysis align with the dimensions of science capital, supporting the validity of the original framework and the reliability of our study. Additionally, a multivariate linear regression identified the choice of STEM careers as the second most significant factor influencing test scores, following social class. Finally, the comparison of socioeconomic status, and the multiple correspondence analysis indicated a potential relationship between science capital and performance.

We acknowledge certain limitations, such as the use of secondary data, given that ENEM data were not collected with the same objectives as this research, and the temporal constraint of focusing on the year 2009. Another limitation was the need to adapt the measurement of science capital by using questions, responses, and a comparison (performance in the Natural Sciences exam) different from those applied in the United Kingdom. Nevertheless, we believe that the larger sample size used in this study overcomes these limitations and contributes theoretically beyond the original proposal. Furthermore, we aim to show that science capital not only influences motivations and identification, but may also enhance performance in science tests. Given Brazil's high levels of social inequality (UNITED NATIONS DEVELOPMENT PROGRAM, 2019), we emphasize the importance of science education research that addresses these disparities. Through the lens of science capital, we seek to highlight how social inequality impacts candidates' performance on the ENEM, and advocate for democratizing access to scientific knowledge.

Our results suggest that the concept of science capital reveals the unequal access to, and identification with, science driven by various social issues. In developed countries, science capital has been used to predict interest in scientific careers and inform public policies. In contrast, within the highly unequal contexts of developing countries, it highlights how science contributes to social and educational disparities (Diamond, 2020; Du & Wong, 2019). We emphasize that science, like culture, is part of a legitimate culture dominated by the upper classes and introduced into schools through cultural arbitrariness (Lima Júnior *et al*., 2014). Therefore, STEM education must address its foundational principles and language while considering social class differences, to ensure a genuinely democratic education that does not reinforce class inequalities.

References

AMÉRICO, B. L.; LACRUZ, A. J. The school environment and its performance: analysis of the scores obtained by schools from the state of Espírito Santo in the nationwide exam Prova Brasil, using multiple linear regression. **Brazilian Journal of Public Administration**, v. 1, n. 51, p. 854-878. 2017. doi: 10.1590/0034-7612160483.

ARCHER, L.; DAWSON; E.; DEWITT, J.; SEAKINS, A.; WONG, B. "Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. **Journal of Research in Science Teaching**, v. 52, p. 922-948. 2015. doi:10.1002/tea.21227

ARCHER, L.; DEWITT, J.; OSBORNE, J. Is science for us? Black students' and parents' views of science and science careers. **Science Education**, v. 99, n. 2, p, 199-237. 2015. doi:10.1002/sce.21146

ARCHER, L.; DEWITT, J.; OSBORNE, J.; DILLON, J.; WILLIS, B.; WONG, B. Science aspirations, capital, and family habitus: How families shape children's engagement and identification with science. **American Educational Research Journal**, v. 49, n. 5, p. 881-908. 2012. doi:10.3102/0002831211433290

ARCHER, L.; DEWITT, J.; OSBORNE, J.; DILLON, J.; WILLIS, B.; WONG, B. 'Not girly, not sexy, not glamorous': Primary school girls' and parents' constructions of science aspirations. **Pedagogy, Culture & Society**, v. 21, n. 1, p. 171-194. 2013. doi:10.1080/14681366.2012.748676

ARCHER, L.; DEWITT, J.; WILLIS, B. Adolescent boys' science aspirations: Masculinity, capital, and power. **Journal of Research in Science Teaching**, v. 51, n. 1, p. 1-30. 2014. doi:10.1002/tea.21122

ARCHER, L.; MOOTE, J.; MACLEOD, E.; FRANCIS, B.; DEWITT, J. **ASPIRES 2: Young people's science and career aspirations, age 10-19**. London: UCL Institute of Education. 2020.

ARCHER, L.; OSBORNE, J.; DEWITT, J.; DILLON, J.; WONG, B.; WILLIS, B. **ASPIRES: Young people's science and career aspirations, age 10-14**. London: King's College London. 2013.

BARROSO, M. F.; RUBINI, G.; SILVA, T. Dificuldades na aprendizagem de Física sob a ótica dos resultados do Enem [Physics learning difficulties from the perspective of ENEM results]. **Revista Brasileira de Ensino de Física**, v. 40, n. 4, p. 1-23. 2018. doi: 10.1590/1806-9126-RBEF-2018-0059

BØE, M. V.; HENRIKSEN, E. K. Expectancy-value perspectives on choice of science and technology education in late-modern societies. In E. K. Henriksen, J. Dillon, & J. Ryder (Eds.), **Understanding student participation and choice in science and technology education**. Dordrecht: Springer. 2015. p. 17-29. doi:10.1007/978-94-007-7793-4_2.

BOURDIEU, P. Avenir de classe et causalité du probable [Class Futures and the Causality of the Probable]. **Revue française de sociologie**, v. 15, n. 1, p. 3-42. 1974. doi: 10.2307/3320261

BOURDIEU, P.; PASSERON, J.-C. **The inheritors**: French students and their relation to culture. Chicago: The University of Chicago Press. 1979.

BOURDIEU, P.; PASSERON, J.-C. **Reproduction in education, society and culture**. Great Britain: Sage Publications. 1990.

BOURDIEU, P. Les trois états du capital culturel [The three states of cultural capital]. **Actes de la recherche en sciences sociales**, v. 30, n. 1, p. 3-6. 1979. doi:10.3406/arss.1979.2654

BOURDIEU, P. **Distinction**: a social critique of the judgement of taste. Cambridge: Harvard University Press. 1984.

BOURDIEU, P. The forms of capital. In RICHARDSON, J. (Ed.) **Handbook of Theory and Research for the Sociology of Education**. New York: Greenwood. 1986. p. 241-258.

COOPER, G.; BERRY, A. Demographic predictors of senior secondary participation in biology, physics, chemistry and earth/space sciences: students' access to cultural, social and science capital. **International Journal of Science Education**, v. 42, n. 1, p. 151-166. 2020. doi:10.1080/09500693.2019.1708510

DEWITT, J.; ARCHER, L. Who aspires to a science career? A comparison of survey responses from primary and secondary school students. **International Journal of Science Education**, v. 37, n. 13, p. 2170-2192. 2015. doi: 10.1080/09500693.2015.1071899

DEWITT, J.; ARCHER, L. Participation in informal science learning experiences: The rich get richer? **International Journal of Science Education, Part B**, v. 7, n. 4, p. 356-373. 2017. doi:10.1080/21548455.2017.1360531

DEWITT, J.; ARCHER, L.; MAU, A. Dimensions of science capital: Exploring its potential for understanding students' science participation. **International Journal of Science Education**, v. 38, n. 16, p. 2431-2449. 2016. doi:10.1080/09500693.2016.1248520

DEWITT, J.; NOMIKOU, E.; GODEC, S. Recognising and valuing student engagement in science museums. **Museum Management and Curatorship**, v. 34, n. 2, p. 183-200. 2019. doi: 10.1080/09647775.2018.1514276

DIAMOND, A. H: The social reproduction of science education outcomes for high school students in Israel. **British Journal of Sociology of Education**, v. 41, n. 7, p. 1029-1046. 2020. doi: 10.1080/01425692.2020.1806040

DU, X., & WONG, B. Science career aspiration and science capital in China and UK: A comparative study using PISA data. **International Journal of Science Education**, v. 41, n. 15, p. 2136-2155. 2019. doi:10.1080/09500693.2019.1662135

EDELEN, M. O.; REEVE, B. B. Applying item response theory (IRT) modeling to questionnaire development, evaluation, and refinement. **Quality of life research**, 16, n. 1, p. 5-18. 2007. doi: 10.1007/s11136-007-9198-0

ESSEX, J.; HAXTON, K. Characterising patterns of engagement of different participants in a public STEM-based analysis project. **International Journal of Science Education Part B**, v. 8, n. 2, p. 178-191. 2018. doi:10.1080/21548455.2017.1423128

EMBRETSON, S. E.; REISE, S. P. **Item response theory**. Mahwah, New Jersey: Psychology Press. 2013.

GREENACRE, M. **Correspondence analysis in practice**. Florida: CRC press. 2017.

HAIR, J. F.; BLACK, W. C.; BABIN, B. J.; ANDERSON, R. E.; TATHAM, R. L. **Multivariate data analysis**. 7 ed. New Jersey: Prentice Hall. 1998.

JENSEN, E.; WRIGHT, D. Critical response to Archer et al. (2015) "Science capital": A conceptual, methodological, and empirical argument for extending Bourdieusian notions of capital beyond the arts. **Science Education**, v. 99, n. 6, p. 1143-1146. 2015. doi:10.1002/sce.21208

JONES, M. G.; ENNES, M.; WEEDFALL, D.; CHESNUTT, K.; CAYTON, E. The development and validation of a measure of science capital, habitus, and future science interests. **Research in Science Education**. v. 51, p. 1549-1565. 2020. https://doi.org/10.1007/s11165-020-09916-y

KING, H.; NOMIKOU, E.; ARCHER, L.; REGAN, E. Teachers' understanding and operationalisation of 'science capital'. **International Journal of Science Education**, v. 37, n. 18, p. 2987-3014. 2015. doi:10.1080/09500693.2015.1119331

King, H.; Nomikou, E. Fostering critical teacher agency: the impact of a science capital pedagogical approach. **Pedagogy, Culture & Society**, v. 26, n. 1, p. 87-103. 2018. doi: 10.1080/14681366.2017.1353539

KLEINKE, M. Influência do status socioeconômico no desempenho dos estudantes nos itens de física do Enem 2012 [Influence of socioeconomic status on students performance in physics items at Enem 2012]. **Revista Brasileira de Ensino de Física**. v. 39, n. 2, p. 1-19. 2017. doi: 10.1590/1806-9126-rbef-2016-0081.

LIMA JÚNIOR, P.; SILVEIRA, F. L. D.; OSTERMANN, F.; PINHEIRO, N. C. A Física como uma construção cultural arbitrária: Um exemplo da controvérsia sobre o status ontológico das forças inerciais [Physics as an arbitrary cultural construction: An example from the controversy on the ontological status of inertial forces]. **Revista brasileira de pesquisa em educação em ciências**. V. 15, n. 1, p. 195-217. 2014.

MACQUEEN, J. Some methods for classification and analysis of multivariate observations. In: JERZY NEYMAN (Ed), **Proceedings of the Berkeley Symposium on Mathematical Statistics and Probability**, Berkeley: University of California Press. 1967. p. 281-297.

MINISTÉRIO DA EDUCAÇÃO. A segunda maior prova de acesso ao ensino superior do mundo [The second largest exam for access to higher education in the world]. 2015, October 05. Retrieved from: http://portal.mec.gov.br/ultimas-noticias/418-enem-946573306/31151-a-segunda-maior-prova-de-acesso-ao-ensino-superior-do-mundo.

MOOTE, J.; ARCHER, L.; DEWITT, J.; MACLEOD, E. Who has high science capital? An exploration of emerging patterns of science capital among students aged 17/18 in England, **Research Papers in Education**. v. 36, n. 4, p. 402-422. 2019. doi: 10.1080/02671522.2019.1678062

MOOTE, J; ARCHER, L; DEWITT, J; MACLEOD, E. Science capital or STEM capital? Exploring relationships between science capital and technology, engineering, and maths aspirations and attitudes among young people aged 17/18. **Journal of Research in Science Teaching**, v. 57, n. 8, 1228-1249. 2020. https://doi.org/10.1002/tea.21628

MORIS, C. H. A. A. **Devagar a tartaruga vai longe? As relações do science capital e do capital cultural com o desempenho no Exame Nacional do Ensino Médio**. 2021. Dissertação (Mestrado em Educação para a Ciência) Programa de Pós-Graduação em Educação para a Ciência, Universidade Estadual Paulista, Bauru.

MORIS, C. H. A. A. MASSI, L. NASCIMENTO, M. M. A educação em ciências e a teoria dos capitais de Bourdieu: uma revisão crítica do conceito de science capital. **Investigações em Ensino de Ciências**, v. 27, n. 1, p. 367–387, 2022.

MUJTABA, T.; SHELDRAKE, R.; REISS, M. J.; SIMON, S. Students' science attitudes, beliefs, and context: Associations with science and chemistry aspirations. **International Journal of Science Education**, v. 40, n. 6, p. 644-667. 2018. doi:10.1080/09500693.2018.1433896

MURAKI, E. Fitting a polytomous item response model to Likert-type data. **Applied Psychological Measurement**, v. 14, p. 59-71. 1990. Retrieved from: http://hdl.handle.net/11299/107784.

NASCIMENTO, M. M.; CAVALCANTI, C.; OSTERMANN, F. Uma busca por questões de Física do ENEM potencialmente não reprodutoras das desigualdades socioeconômicas. **Revista Brasileira de Ensino de Física**, v. 40, n. 3, 2018.

Nogueira, M. A. Capital cultural [Cultural capital]. In CATANI, A. M.; NOGUEIRA, M. A.; HEY, A. P.; MEDEIROS, C., C., C. (Orgs.). **Vocabulário Bourdieu [Bourdieu vocabular]**. Belo Horizonte: Autêntica Editora. 2017. p. 103-106.

NOMIKOU, E.; ARCHER, L.; KING, H. Building 'science capital' in the classroom. **School Science Review**, v. 98, n. 365, p. 118-124. 2017.

REGAN, E.; DEWITT, J. Attitudes, interest and factors influencing STEM enrolment behaviour: An overview of relevant literature. In HENRIKSEN, E. K.; DILLON, J.; RYDER J. (Eds.), **Understanding student participation and choice in science and technology education**. Dordrecht: Springer. 2015. p. 63–88.

ROCHA, L. E. C.; NASCIMENTO, L. Assessing Student's Achievement Gaps between Ethnic Groups in Brazil. **Journal of Intelligence**, v. 7, n. 7, p. 1-17. 2019. doi: 10.3390/jintelligence7010007

SAMEJIMA, F. Estimation of latent ability using a response pattern of graded scores. **Educational Testing Service Research Bulletin Series.** 1968. doi: 10.1002/j.2333-8504.1968.tb00153.x

SALEHJEE, S.; WATTS, M. Science Lives: School choices and 'natural tendencies', **International Journal of Science Education**, v. 37, n. 4, p. 727-743. 2015. doi: 10.1080/09500693.2015.1013075

SIRIN, S. R. Socioeconomic status and academic achievement: A meta-analytic review of research. **Review of educational research**, v. 75, n. 3, p. 417-453. 2005. doi: https://doi.org/10.3102/00346543075003417

TABER, K. S. The use of Cronbach's alpha when developing and reporting research instruments in science education. **Research in Science Education**, v. 48, p. 1273-1296. 2018. doi: 10.1007/s11165-016-9602-2

TAKANE, Y.; DE LEEUW, J. On the relationship between item response theory and factor analysis of discretized variables. **Psychometrika**, v. 52, p. 393-408. 1987. doi: 10.1007/BF02294363

TRAVITZKI, R.; CALERO, J.; BOTO, C. What does the National High School Exam (ENEM) tell Brazilian society? **CEPAL Review**, v. 113, n. 9, 157-174. 2014. doi: 10.18356/5db107a1-en.

TRAVITZKI, R.; FERRÃO, M. E.; COUTO, A. P. Desigualdades educacionais e socioeconómicas na população brasileira pré-universitária: Uma visão a partir da análise de dados do ENEM [Educational and socio-economic inequalities of pre-university Brazilian population: A view from the ENEM data]. **Arquivos Analíticos de Políticas Educativas**, v. 24 n. 74, 1-32. 2016. doi: 10.14507/epaa.24.2199

UNITED NATIONS DEVELOPMENT PROGRAMME (UNDP) Human Development Report 2019. (2019). Retrieved from: https://hdr.undp.org/system/files/documents/hdr2019.pdf. Accessed: 24 apr. 2024.

WOODS-GROVES S.; EAVES R. C.; WILLIAMS T. O. Exploratory factor analysis of the Human Behavior Rating Scale: a rural population. **Psychological Reports**, v. 109, n. 3, p. 785-802. 2011. doi: 10.2466/03.09.10.20.PR0.109.6.785-802

Recebido em: 23/04/2024
Aprovado em: 20/12/2024