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Educação Matemática Debate

The alphanumeric image: a discursive anthropology of Mathematics Education

Abstract: The research examined how language, number, and image interact in Mathematics Education, arguing that their separation results from historical processes. It discusses the implications of this separation within schools and in public opinion. Based on Michel Pêcheux's discursive theory and anthropological perspectives, it analyzes high-performing OBMEP answers to understand how their linguistic and numerical practices are articulated. The results indicate that variation in statements and their cultural variety do not affect mathematical accuracy. The article is organized into four parts: 1) presentation of the argument; 2) review of studies on Mathematics, culture, and language; 3) analysis of OBMEP responses; 4) suggestions for future research and educational strategies, exploring intersections between the BNCC and collaborative initiatives between Mathematics and Portuguese Language.

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La imagen alfanumérica: una antropología discursiva de la Educación Matemática

Resumen: La investigación examinó lenguaje, número e imagen en la Educación Matemática, argumentando que su separación resulta de procesos históricos, además de discutir sus implicaciones en la escuela y la opinión pública. Basada en la teoría discursiva y perspectivas antropológicas de Michel Pêcheux, analiza respuestas de OBMEP para comprender cómo se articulan sus prácticas lingüísticas y numéricas. Los resultados indican que la variación en las afirmaciones y su variedad cultural no afectan la precisión matemática. El artículo se organiza en: 1) presentación del argumento; 2) revisión de estudios sobre matemáticas, cultura y lenguaje; 3) análisis de las respuestas; 4) sugerencias para investigaciones y estrategias educativas, explorando intersecciones entre la BNCC e iniciativas de colaboración entre las Matemáticas y la Lengua Portuguesa.

Palabras clave: Antropología. Educación Matemática. Discurso. No Verbal. Tecnología.

A imagem alfanumérica: uma antropologia discursiva da Educação Matemática

Resumo: A pesquisa examinou como linguagem, número e imagem interagem na Educação Matemática, discutindo que sua separação resulta de processos históricos e as implicações desse afastamento na escola e na opinião pública. Pela teoria discursiva de Michel Pêcheux e perspectivas antropológicas, analisam-se respostas de alto desempenho da OBMEP para compreender a articulação entre suas práticas linguísticas e numéricas. Os resultados indicam que a variação nos enunciados e sua amplitude cultural não afetam a precisão matemática. Organizou-se o artigo em quatro partes: 1) apresentação do argumento; 2) revisão de estudos sobre Matemática, cultura e linguagem; 3) análise das respostas da OBMEP; 4) sugestões para pesquisas futuras e estratégias educacionais, explorando interseções entre a BNCC e iniciativas colaborativas entre Matemática e Língua Portuguesa.

Palavras-chave: Antropologia. Educação Matemática. Discurso. Não Verbal. Tecnologia

1 Introduction

This study analyzes the discursive interaction of words, numbers, and images in mathematics education as cultural artifacts. We argue that the historical reification of writing as solely alphabetic has fragmented didactic reasoning. This separation isolated mathematics and reduced counting and reading to instrumental skills, measured by formal usage, rather than understanding them as broad expressions of human ability and creativity. In this way, the linear use of written language naturalizes the idea that the *verbal* and the *number* faculties are distinct, rather than complementary, cognitive aspects.

In the aftermath of previous studies (Lourenço, 2012a, 2012b, 2015, 2024) on multimodal discursive properties in *Olimpíada Brasileira de Matemática das Escolas Públicas* [Brazilian Mathematics Olympiad for Public Schools — OBMEP] answers (2010-2013), this research proposes an approximation between mathematics and the Portuguese language as connected practices. The aim is to unify their perception based on common cultural and linguistic clues, such as diacritical marks in notation, or verbal marks, such as the act of counting, which evidences a shared basis in the constitution of meaning.

To construct this object of study, we chose the theoretical framework of Michel Pêcheux's discourse analysis (DA). The methodological approach observed its logical and syntactic sequence to identify autonomous discursive sequences (ADS) in the solutions. This connection between nouns, verbs, and prepositions is central to its original theoretical formulation. An illustrative example is the phrase *The market regulates itself*, whose interpretative autonomy of language masks not the meaning but the ideological origin of the statement, legitimizing seemingly neutral conclusions. Similarly, linguistic use in mathematics generates *cognitive enchantment* by suspending interpretative criticism (Dunn, 2008).

Expanding this perspective, this research includes numbers as discursive operators in ADS, mediated by images that function as deixis, anaphoras, and quantifiers. This approach is grounded in investigations that underpin the study of non-verbal materialities, beginning with silence (Orlandi, 1995) and extending to the image (Souza, 1998). Analysis of the modes of signification of this knowledge in students' answers reveals possibilities for complementary practices and makes the reasons for this historical separation an epistemological *residue* to be investigated in this study (Lourenço, 2012a).

The research results indicated that the highest grades presented an unsystematic and ad hoc use of mathematical language and grammar notation (Lourenço, 2015). This use was called *metaimage*, to reveal how verbal, numerical, and visual elements are organized in an integrated way in meaning production.

The constant presence of the simultaneous use of the three elements in the tests resulted in questioning the current rigidity in the disciplinary division in teaching. From this, the central hypothesis of this article was formulated: philosophical conceptions and historical practices shaped the perception of writing, leading to fragmentation in the use of symbolic systems. OBMEP, in turn, is a counterexample to this didactic disarticulation, valuing the integration of interdisciplinary knowledge.

Furthermore, this non-formal and integrative use of symbolic systems is not restricted to students and can be identified historically in practices such as the instrumental application of the Cartesian plane in non-linear algebra and the Argand-Wessel plane for complex numbers. Just as these systems come together to solve problems, students use the three elements — words, numbers, and images — informally to connect ideas and formulate solutions.

Thus, the article is organized into four parts: (1) a presentation of the research and the concept of metaimage, (2) an establishment of the theoretical bases with a review of historical, philosophical, and anthropological research, (3) a discussion of the implications for pedagogical practice, and (4) an analytical exercise demonstrating the identification of metaimages and research proposals and educational strategies.

2 Argument context

Difficulty with mathematics is a recurring theme in society, the media, and the school experience. Initiatives such as OBMEP, however, suggest that this could change, as student participation reaches millions of students, making it possible to challenge this perception.

Although historical studies (Pimm, 2018; Halliday, 1974) highlight the intrinsic relationship between the linguistic and mathematical aspects of formal education, these are often treated in isolation. This disconnect also has implications outside the classroom, such as difficulty interpreting financial data or everyday calculations (Mackenzie, 2006).

This disruption has an impact on Brazil's results in international assessments (PISA) and in national curriculum documents — *Base Nacional Comum Curricular* [Common National Curriculum Base (BNCC)]; *Parâmetros Curriculares Nacionais* [National Curriculum Parameters (PCN)]. Students tend to view terms like *of* (*de*) or *by* (*por*) as mere words (Eduardo, 2023). OBMEP, on the other hand, evaluates and recognizes this non-standardized knowledge, resuming the critical and argumentative dimension (Fernandes and Mascia, 2020).

To investigate this dichotomy and propose an analysis that recognizes the intrinsic relationship between reading and counting, Section 2 presents the theoretical formulation of DA, the methodology, and the philosophical and cultural bases of the writing systems underpinning the symbolic nature of mathematical discourses.

3 Theoretical and analytical framework

To analyze this dichotomous perception, we examine aspects of the historical and cultural transition from pictograms to writing systems. Next, we consider the contributions of DA and anthropology to examine how these artifacts result from the systematic production of symbolic technologies (Bishop, 1970).

To detail the use of images and numbers as cognitive instruments of reasoning, we observed how the conceptions of techniques are constructed from philosophical, historical, and cultural beliefs (Arens, 1984). This procedure, called *technography* (Sigaut, 1994), describes the ideological, material, and cognitive constitution of these graphic artifacts from an anthropological and linguistics perspective. Furthermore, it relates this learning process to research on mathematics education, analyzing limitations, similarities, and differences with the present proposal. This criticism will later lead to the distinction between anthropological subjects and objects as possibilities for pedagogical exploration.

At this point, it is necessary to establish, from the outset, a precise terminology to argue that tradition arises from a *reification of the image*. In semiotics (Sebeok and Danesi, 2000; Wilder, 1981), *naturalizing* means making a practice, belief, or process part of the everyday flow, so that its existence is not questioned. *Objectifying*, on the other hand, consists of transforming an idea, person, or living being into an object, instrumentalizing its existence for a specific purpose (Nöth, 1994).

Therefore, *reification* describes the process by which a social representation acquires legitimate value and *autonomous* existence, such as stereotypes about mathematics that obscure their origin in the language. The use of this concept in the article is twofold: first, as an unconscious historical process, exemplified by Greek phonetic writing which, like commodity fetishism (Marx), distances the two coexisting modes in the same system; the second use takes the concept as a conscious learning process (3.1), articulating Sfard (1991), Vygotsky (2012),

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and Radford (2011) to integrate cultural aspects in the construction of arguments, bringing the individual closer to the object.

The literature on mathematics education has long recognized the need to combine reading and counting. To collaborate with previous studies, it is essential to use terminology that aligns with these joint pedagogical practices. These initiatives integrate mathematical knowledge into language, and, in the same way, they are convinced that this process is based on culture.

However, there is a dual terminological perception about the concept of number that seeks to account for this articulation to define its nature and applications. Thus, several times, the field produced terms, such as *numeralização* [numericization], *literacia quantitativa* [numeracy, quantitative literacy] (Campetti and Dorneles, 2022), *numeracia* [numeracy] (Crowther, 1959), *alfabetização matemática* [mathematical alfabetization] (Santos, 2024), *literacia matemática* [mathematical literacy] (D'Ambrosio, 1999), and *numeramento* [numeracy] (Mendes, 1995; Fonseca, 2015).

Writing, fundamentally an alphanumeric system, linearizes cognition, allowing us to discuss numbers and words as non-images. Thus, the aim is to recognize and explore the alphanumericization inherent in writing rather than connecting language and mathematics. Reflection on the processes of *alphanumericization* elsewhere will be necessary, given that coordination is needed rather than approximation. However, this distinction will be maintained with this caveat for analytical purposes.

To analyze how studies in mathematics education address these cultural and linguistic issues, the next step is to establish a theoretical and analytical framework of the notion of discourse, anchored in the anthropological perspective. This involves exploring the conditions of the production of statements as well as the philosophical, historical, and cultural beliefs that shape them. In this context, the Greek origin of the writing system will be analyzed as a reification of the image, seeking to overcome the dichotomy between language and number.

3.1 Conditions of production of the discourse

The theoretical-methodological framework adopted articulates three epistemological axes. The first axis has linguistics as the baseline; however, criticism recognizes the partial autonomy of language. Language is accepted as a system (*langue*); however, its Saussurean individual idealization is rejected (*parole*). DA, therefore, constructs and uses the subject-form, whose process is formulated in the existence of two forgetfulnesses: the impossibility of transcending ideological formation and the selection of words that erase those ideologies. Consequently, discursive formations emerge in the historical and cultural selections of statements (Foucault, 1969 *apud* Fishing, 1997).

The second axis, psychoanalysis, describes these choices of signifiers as guided by affiliations of desire (Althusser, 1969 *apud* Fishing, 1997) and by the subjection of the ideological state apparatuses (ISA), i.e., institutions that reproduce dominant ideologies.

Finally, in the third axis, Marxism, we determine that individual expression occurs through class relationships, supporting the premise that speech implies the subject and the subject implies ideology. This may explain the low recognition of the ideological power of mathematics in the language (Pêcheux, 1997). Likewise, in DA, the epistemological autonomy of *mathematicians* is interpreted as a manifestation of Platonist subjection, expressed in the Münchhausen effect (Pêcheux, 1997), which causes the subjects *to pull themselves together*.

Outside of Marxism, similarly, it is possible to agree on the impact of the power of *language games* (Wittgenstein, 1953), which demonstrate how language shapes, in degrees and

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nuances, thought and action, rather than merely conveying meaning. Thus, the three articulated axes — linguistics, psychoanalysis, and Marxism — underpin the theoretical-methodological framework adopted.

This theoretical articulation allows us to hypothesize how symbols are conceived as material signs in language, analyzing the effects of meaning and paraphrases that reflect historical affiliations. The following subsection discusses the methodological construction of the corpus, based on these premises.

3.2 Methodology

The initial research, conducted between 2011 and 2015, involved the collection of a corpus of 42 questions applied between 2010 and 2013. These questions were selected in collaboration with the test preparation committee, including the six lowest and six highest scores for each question. The initial objective of this stage was to compare the highest and lowest performance scores to identify discursive and multimodal patterns. Therefore, the objects of this study were the highest and lowest-performing answers to the 42 OBMEP questions.

However, the analysis revealed that 100% of the lowest notes did not present an argument structure. These answers contained only isolated numerical expressions, such as *54 – 2 = 52*, or disjointed graphic records without syntactic or diagrammatic organization. This lack of textual chaining made the initial comparison unfeasible since the constitution of ADS presupposes syntactic and referential relations.

Given this limitation, we reformulated the analytical approach. Instead of comparing performances, the new objective began to examine the multimodal relationship in the highest-scoring answers. Thus, the analysis stopped focusing on the effectiveness of the answers and began to explore the internal organization of the statements, comparing the articulation between verbal language, numerical representation, and graphic elements.

The methodological reformulation yielded a corpus of 31 questions, comprising a total of 186 highest-scoring answers. The new criterion became the simultaneous presence of text, numbers, and diagrams. With this procedure, it was no longer necessary to observe numerical efficiency, which had already stabilized, despite several resolution strategies, due to the students' linguistic mastery in structuring mathematical reasoning.

This observation led to the hypothesis that flexibility in the organization of statements should not be interpreted as a mere stylistic variation (Garnica, 1996), but as historical-cultural patterns manifested in the creative appropriation of the writing system (Steensen; Johansen, 2016).

The present investigation stems from this methodological reformulation and revisits the original question of the relationship between linguistics and non-verbal meaning (Lourenço, 2012a). It starts from the observation that, unlike the traditional school combination of these elements (Krämer and Ljungberg, 2016, O'Halloran e Smith, 2011), their use in tests went beyond the subjects. In this way, it suggests that the possibilities of ideological formations delimit the duality of enunciative positions that the subjects may or may not occupy.

3.3 Mathematical discourse as a symbolic system

The adopted theory understands that the belief in the independence of mathematics regarding human thought is constituted and manifested in legitimate statements (ADS). In these, the very meaning of mathematics in language and culture paradoxically reinforces this belief.

The word *symbol* comes from the Greek *symbolon* (σύμβολον), the union of *sym-* (συν, *together*) and *ballo* (βάλλω, *to throw*). Originally, *symbolon* was a broken object used as a sign of recognition of a *reunion*. This origin reveals that a *symbol* creates a *connection of parts* mediated by the recognition that each is something beyond itself. Paradoxically, symbols affirm the independence of mathematics, separating the thinker from the thought.

To overcome this inherent contradiction, explicit ideology is necessary to disassociate the human origin of mathematical discourse as external and prior to the human. In tests, ADS symbolize this construction of knowledge, legitimized by the grade, as successful enunciative representations. This split creates the discourse on access to the *non-human* and the independent nature of mathematical truth.

Anthropological analyses and DA converge in considering mathematics as a symbolic system (Abrahamson et al., 2006; Andersson and Wagner, 2021; Bishop, 1988; Jablonka, Wagner and Walshaw, 2013; Silva and Silva, 2023; Wilder, 1981). In these approaches, knowledge is organized and symbolically externalized in rituals through technologies. In this way, these quantitative manipulations in language formalize cognitive constructs (Radford, 2011), configuring techniques that systematize the applications of high social value.

Numerical operations, in addition to their practical function, generate metaphysical debates among experts and reinforce the dichotomy between the *initiated* and the *profane* due to the ritualization of mathematical knowledge, attributed to Greek influence: Platonic (idealization) and Aristotelian (reduction to the verbal). The importance of considering cultural knowledge as a non-neutral technology is reflected in the curricula (Januario and Lima, 2017; Brasil, 2014) and has previous bases. The factors that led to this linear conception of meaning will be discussed below.

3.4 The basis of philosophical reductions

Common sense often presents the numbers as isolated symbols from the language, belonging to a fixed set of rules, ignoring their historical and cultural evolution and reinforcing a dual perception of cognition in relation to the word. This vision transformed something hybrid into something rigid, marginalizing other semiotic modalities. (Walter, 1986).

In *De Interpretatione*, Aristotle argues that writing derives from speech (Arens, 1984), subordinating it and reducing its technological role (Souza, 1998). This traditional conception minimizes the autonomy of mathematics in the language as a means of signification, reinforcing a logocentric hegemony (D'Ambrosio, 1999). Linguistic criticisms of this position reveal how Aristotle's view of the writing system is subordinate to the verbal system, functioning only as a visual translation of words (Coulmas, 2003; Givon, 2001).

Platonism, in turn, attributes reality to mathematical possibilities *a priori* (D'Ambrosio, 1999; Bishop, 1988; Borba and Skovsmose, 1997; Silva and Silva, 2023), defining them as existing in an ideal world accessible through numerical exercise. Influenced by Aristotle and Plato, the consolidation of the phonetic code structured a large part of school cognition, reinforcing, for example, the capitalist logic that results in the erasure of different symbolic materialities (Ellison and Reinöhl, 2024; Dehaene, 1992; Dowker and Nuerk, 2016).

This structuring also impacted cultural perceptions, allowing stereotypes about people and individuals based on gender, race, and class (Andersson et al., 2022). While the Greek tradition consolidated its numerals through letters, other cultures developed distinct systems, adapting non-linear symbolic conventions and combining letters, numbers, and images in different ways.

3.5 The sense effect of the encoded images

The evolution of number systems linked to images has always enabled the representation of abstract quantities. From the Ishango bone (c. 20,000 BC) (Huylebrouck, 2019) to computational systems, the cultural need to count and measure drove methods of representation (Grice et al., 2024).

Early civilizations used additive systems, such as Egyptian hieroglyphics and cuneiform writing, limited by the lack of abstraction (Chrisomalis, 2010). The first alphabet, Proto-Sinaitic, appeared around 1900 BC in Egypt, marking the beginning of phonetic writing. The Wadi el-Hol inscriptions, dating from approximately the same period, also exemplify the early use of the alphabet (Darnell et al., 2005).

In ancient Greece (c. VIII BC), counting combined orality and writing. Later, the Attic system emerged (c. VII-VI century BC) using strokes and letter symbols, while the Ionic (c. V BC) standardized letters with fixed numeric values, facilitating calculations but dualizing phonetic and numerical functions. The Roman system (c. III BC — Middle Ages) also used letters (I, V, X, L, C, D, M) with additive-subtractive rules, without positionality. The Indo-Arabic system, adopted in the West from the 12th century onwards, transformed European mathematics by introducing positionality and zero.

Alphabetic technology has a long tradition of classical perspectives, including studies on transitioning from orality to writing as a reorganization of human thought (Ong, 2002). Other approaches, based on *the ladder of abstraction, place this transition as a technological stage that reduced reality to linear codes,* which may be surpassed in the future (Vilém Flusser). However, these perspectives understand reification as the progress of complexity. This work follows another direction, in which the fragmentation of cognition by technology is identified first, before returning to its genesis. As discussed above, we believe that the development of this technology will lead to the return of alphanumericization.

As proposed, equating the production pattern of phonetic writing with that of the human organism is counterproductive (Dehaene, 2017), since systems such as *Varnamālā*, Sanskrit writing, demonstrate flexibility in the relationship between sound and symbol.

In contexts such as Chinese, the *term* Zìmǔ designates the original spelling, while *Pinyin zìmǔ* associates the concept with Romanization (Menninger, 1992). Other systems, such as Babylonian (positional) and *quipus* — the systematic set of ropes and knots used by the Incas for numerical operations — demonstrate materially diverse alternatives (Sproat, 2023).

These cultural differences show that specific contexts shaped alphabetical writing and can contribute to reflections on disciplinary approaches. The naming of the Greek system as *alphabetical* externalized the numbers from the language.

4 Culture, language, and technology

The previous section established the scope of analysis, the methodology, and the philosophical-epistemological bases of the discourses of mathematics as a symbolic system, arguing that the historical standardization of phonetic and linear writing consolidated this technology as a representation of thought.

This section explores the connection between anthropology and mathematics education, outlining how culture can contribute to bringing mathematics closer to the Portuguese language. A sign of this possibility is the dual meaning (*to tell* and *to count*) of the Portuguese verb *contar* — a central activity to both domains, suggesting recurrence and progression as shared characteristics (Lourenço, 2012b).

Several ethnographic descriptions of institutionalized educational practices reveal that the rules for disciplinary production are generally explained as universal by common sense (Chrisomalis, 2010; Kieran; Forman; Sfard, 2003). Therefore, this narrative aspect of school education in both disciplines implies a legitimized discourse that isolates one from the other.

This notion of purity is seen as ethnocentrism and leads to the idea that there is only one *correct* way to execute mathematical operations (Gurgel, 2007; Lave, 2015; Oers, 2003; Borba, Skovsmose, 1997), which standardizes the historically recognized form, while other formations are seen as alternative or incorrect.

4.1 Anthropology and Mathematics Education

Anthropology has as its *modus operandi* looking, listening, and writing (Oliveira, 1996), aiming to understand the internal knowledge of groups through their traditions, patterns, tendencies, and moral and aesthetic preferences (Geertz, 1973; Turner, 1969). The field is characterized by the multiplicity of approaches, reflecting the diversity of conceptions (Laraia, 1986; Schick, Schmidt and Zillinger, 2022).

Historically, its objective was associated with controlling colonies and traditional peoples (Ness and Coleman, 2022), influencing material and mental generalizations based on local logic. Over the years, the definition of culture has evolved, and in 2010, the American Anthropological Association removed the term *science* from its institutional mission. The term has now been reinstated, but this change illustrates the volatility of anthropological dynamics and politics (Wade, 2010).

Understanding how learning theories study culture enables us to conceive mathematics education as an ethnologically significant act (François, Pinxten and Mesquita, 2013; Lave, 2015; Radford, 2011; Silveira and Cunegatto, 2016).

In the sociocultural field, Vygotsky's internalization theory examines the *higher psychological processes* that emerge socially and are internalized individually. This conception underpins the theory of objectification (Radford, 2006, 2011; Presmeg, 2016; Barnham, 2022), which expands Vygotskian theory by emphasizing that knowledge is formed not only through language but also through other senses, in addition to artifacts and cultural interactions.

Theories such as reification (Sfard, 1991) seek to explain how social experience objectifies mathematical concepts, making them manipulable through action, condensation, and reification.

The concept of metaimage articulates the theories of Sfard (reification) and Radford (objectification), considering that there is a historical drift towards the specialization of the image, which has produced an epistemology of discursively autonomous entities. As a consequence, there was a separation between reading and counting practices. The division between writing and numerical notation suppressed nonverbal ways of thinking, such as imagery, reinforcing the dichotomy between language and mathematics.

The following section will address this distinction between objects (number systems) and subjects (beliefs), characterizing this conceptual construction as a technographic process.

4.2 Object *vs.* anthropological subject

In the analysis of the relationship between mathematics education and culture, the distinction between objects — number systems, cognitive technologies — and anthropological subjects — metaphysical beliefs, power relations, ethnicity — stands out. The perception of mathematics as unrelated to culture allows us to use various anthropological theories to change this position. Below is a brief overview of the descriptions of the main groups.

The first group analyzes the structure of mathematics, considering it a system of relations and oppositions that reflects social and cultural organization (Leach, 1976; Lévi-Strauss, 1968). The second, interpretative, examines it as a cultural practice expressed in rituals, beliefs, and traditional knowledge (Geertz, 1989), which will later highlight initiatives such as ethnomathematics. Network theory (Latour, 1987; Santos, 2024) expands this view and considers mathematics as technological practices systematically distributed between humans and artifacts. Similarly, the theory of materiality (Horst and Miller, 2012) investigates the impact of objects and technologies as pedagogical instruments. From this technical perspective, there is the tradition of ethnological criticism of writing (Goody, 1999), but which, as mentioned elsewhere, recognizes the impact of linearity without questioning the alphabetic premise.

The third group examines the political implications, analyzing power relations, inequality, and the economy. This Marxist group (Godelier, 1977) criticizes political-symbolic systems and the reproduction of structures of domination. The fourth group, the cognitive approach, studies aspects of communication, observing how concepts are transmitted and interpreted (Sperber, 1974; Sperber and Wilson, 1986). Finally, the analysis of educational practices can be approached through the recent ontological turn (Descola, 2016), which understands representations as cultural materializations, systematized as epistemological potentialities of the diversity of knowledge.

From this variety of approaches, mathematical practices can be understood as emerging from language amid epistemological disputes, which affects students' appropriation of knowledge. In the research, the analysis of the variation of ADS led to the consideration of these structures as ethnomathematical practices, illustrating how their stylistic variations denote class attributions expressed in individual internalization and social objectification.

4.3 The epistemology of ethnomathematical practices

The two poles described above can be found in the *Programa Etnomatemática*. Aligned with criticism of Platonist influences (Joseph, 2011; Selin, 2000; Borba e Skovsmose, 1997; Eglash, 2000) and explicitly addressing the Aristotelian logocentric tradition (D'Ambrosio, 1984), these studies understand the numerical and quantitative practices as cultural production. They approach this topic from the epistemological formulation of subjects and concepts, to the ethnographic description of practices that become anthropological objects.

This criterion applied to the OBMEP proofs illustrated the tension between individual internalization — in which each student incorporates knowledge in their own way — and social objectification, which standardizes them into a formal and universal system. The question of why this variety did not compromise numerical efficiency led to research in ethnomathematical studies (Aroca-Araujo, 2016), exploring how the field articulates notions of culture, language, and technology (Lourenço, 2018). When classifying these uses, a terminological dispersion that makes it difficult for the public to understand these different perspectives was identified, despite them being grouped under the same concept.

To make the picture even more complex, public opinion and, sometimes, the school itself construct a stereotypical sense (τερεός, stereos, solid) that the prefix *ethno* (ἔθνος, ethnos, *people*, *or group*) refers only to the study of traditional or non-industrialized societies (Netto, 2023). However, instead of awakening an idea of exotic or distant, the term expresses the human and universal characteristic of sharing collective knowledge.

Thus, the pedagogical possibilities of applying anthropological theories to mathematics education were presented. Next, the strategies adopted by the students and their practical implications in the theoretical framework will be analyzed.

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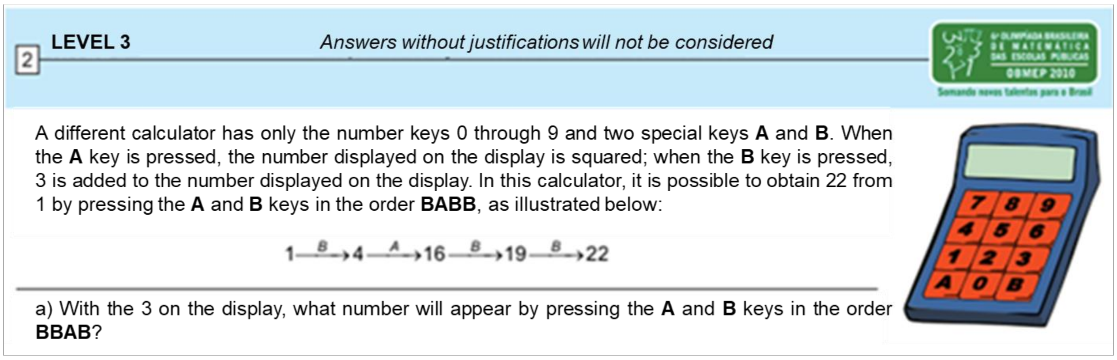
5 An example of an analysis of OBMEP answers

As a result of doctoral research, the concept of metaimage was developed to materialize the systematicity of extragrammatical constructions of language. These strategies imply learning distinct skills, observable in their discursive marks. This article analyzes this specialized use of the image as writing, reified in specific instrumental signs.

Following this, a question will be presented as a practical example: item C, question 1, level 3 of the 2010 test (*Explain why it is not possible to obtain 54 from 2 using the A and B keys*), which involves algebra and arithmetic on a special calculator with keys for squaring and adding 3. The goal is to determine whether obtaining the number 54 from the number 2 is possible using only keys A and B.

Question N3Q1/2010: A different calculator has only the number keys 0 through 9 and two special keys A and B. When the A key is pressed, the number displayed on the display is squared; when the B key is pressed, 3 is added to the number displayed. In this calculator, you can get 22 from 1 by pressing the A and B keys in the order BABB, as illustrated in Figure 1.

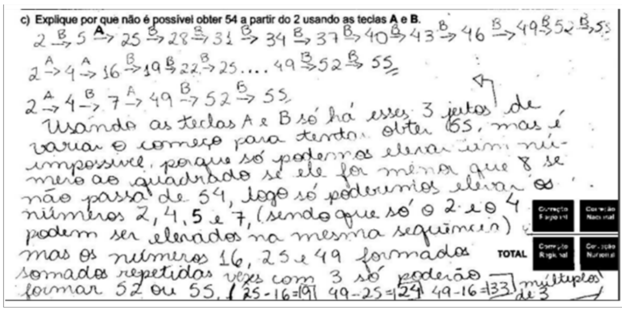

2 LEVEL 3 *Answers without justifications will not be considered*

A different calculator has only the number keys 0 through 9 and two special keys **A** and **B**. When the **A** key is pressed, the number displayed on the display is squared; when the **B** key is pressed, 3 is added to the number displayed on the display. In this calculator, it is possible to obtain 22 from 1 by pressing the **A** and **B** keys in the order **BABB**, as illustrated below:

1 —B→ 4 —A→ 16 —B→ 19 —B→ 22

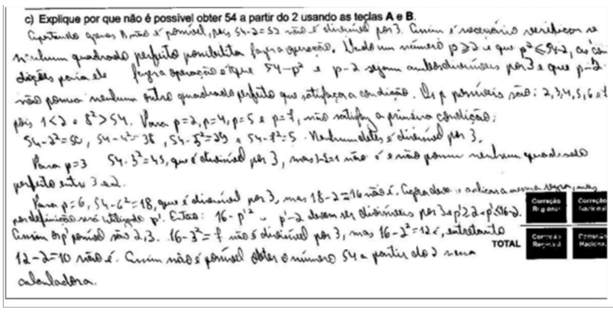
a) With the 3 on the display, what number will appear by pressing the **A** and **B** keys in the order **BBAB**?

Figure 1: Question 1 of level 3 of 2010



Using the A and B keys there are only these. 3 ways to vary the beginning to try to get 65, but it is impossible, because we can only raise a number to the square if it is less than 8 if it is not more than 54, so we can only raise the numbers 2, 4, 5 and 7 (being that only 2 and 4 can be raised in the same sequence) but the numbers 16, 25 and 49 formed added repeatedly with 3 can only form 52 or 55. 25-16 = 9 49-25 = 24 49-16 = 33 multiples of 3.

Figure 2: Response 1 (Research Data)



Pressing only A is not possible, since 54-2=52 is not divisible by 3. So it is necessary to check if no perfect square made it possible to perform the operation. Given a number P ≥ 2 and that p2 ≥ 54 – 2, the conditions for it to perform the operation are that 54-p2 are both divisible by 3 and that p – 2 does not have any other perfect square that satisfies the condition. The possible P are: 2, 3, 4, 5, 6 and 7 since 1 < 2 and 82. 54. For p=2, p=4, p=5 and p=7, it does not satisfy the first condition, 54-22=50, 54 – 42 = 38, 54 – 52 = 29 and 54-72=5. None of them are divisible by 3.

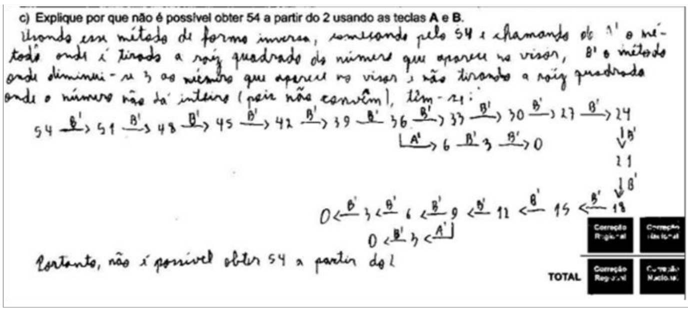
Figure 3: Response 2 (Research Data)

Let's do it the same way as we did in B 54-3 = 51-3 = 48-3 = 45-3 = 42-3 = 39-3 = 36. Note: We will continue using 3, because 36-A = 6-B = 3 we cannot get to the number 2.

Continuing 36-3 = 33 = 3-3 = 27 = [....]

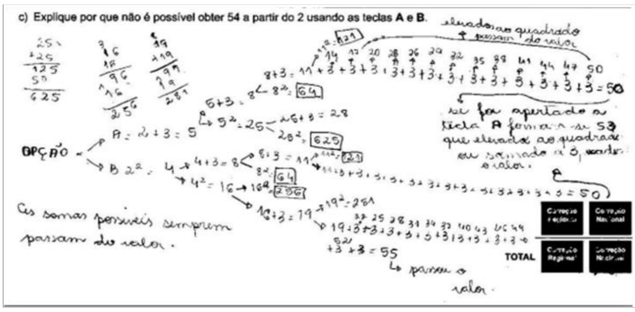
(In all the possible ways shown above) the smallest number we could get to was 3, which using B again, we will find the number 0.

Figure 4: Response 3 (Research Data)



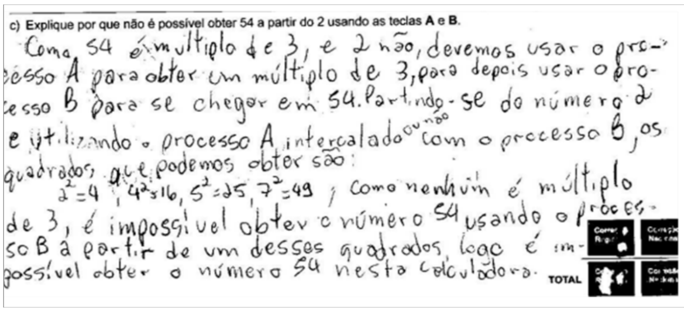
Using this method in reverse, starting with 54 and calling P', the method where you will take the square root of the number that appears on the screen, 0', the method where you subtract 3 from the number that appears on the screen, without taking the square root where the number is not an integer (as it is not convenient), you have: (develops algorithm with arrows and numbers).
Therefore, it is not possible to obtain 54 from 1.

Figure 5: Response 4 (Research Data)



The possible sums always exceed the value. When squared, they exceed the value (^). If the A key is pressed, 53 is formed, which is squared or added to 3.

Figure 6: Response 5 (Research Data)



Since 54 is a multiple of 3, and 2 is not, we must use process A to obtain a multiple of 3, and then use process B to arrive at 54. Starting from the number 2, and using process A interspersed or not with process B, the squares that we can obtain are: 22 = 4 42 = 16 and 52 = 25 72 = 49, since none of them are multiples of 3, it is impossible to obtain the number 54, using process B, from one of these squares, therefore it is impossible to obtain the number 54 in this calculator.

Figure 7: Response 6 (Research Data)

5.1 Analysis of answers

As a consequence of methodological leveling, the answers can be considered effective *a priori*, allowing the analysis to focus on describing their strategies, regardless of the linguistic variety. Three criteria guide this observation: detail — step-by-step with justifications and alternatives *versus* conciseness; formality — technical language and notations *versus* colloquial language; and structural flexibility — centrality of concepts *versus* prioritization of operations.

5.2 Discussion

There is significant variation in approaches, ranging from *step-by-step* guidelines, justifications, and exploration of alternatives (1, 2, 4, 6) to concise explanations focused on the final result, omitting intermediate steps (3, 5). Answer #1, for example, exhaustively explored the numerical possibilities using deictics (*there are only these three ways*) and anaphoras (*if it is less than 8*), reflecting the naturalization of statements and the objectification of knowledge. In contrast, Answer #3 adopted a colloquial approach, with implicit references to the operation *in B* and using graphs to mark the steps without formalizing or explicitly justifying each stage.

Formality also oscillated between technical language with mathematical notations and rigorous structure, approaching an algorithmic style (2, 6), and everyday language with colloquial expressions and less structural rigor (1, 3, 5). The emphasis on mathematical construction was manifested in the exploration of underlying concepts such as divisibility and properties of squares (2, 6), contrasting with the prioritization of the simple execution of operations (3, 5).

When exploring the subjection positions, we observe that, through deictics and anaphoras, #1 demonstrates a less formal tone of numerical exploration, focusing on concepts such as *multiplicity of 3* and *properties of squares* unsystematically. Answer #2, in turn, details with anaphoric sequential language and more formal mathematical notations, citing concepts of *divisibility* and *perfect squares* to justify the impossibility of the result. Answer #3 uses graphics and colloquial language, *relies* on the previous references, and focuses on the results with little emphasis on formal construction.

Answer #4 has algorithms, diagrams as visual proofs, formalizing the square root and subtraction, and uses deictics and anaphoras to reference steps, therefore, a formal position. Answer #5, by simplifying the justification with deictics and relying on the initial statement and generic principles (*multiple of 3*), demonstrates that it relies on the *authority of the statement* of the question. Finally, Answer #6, similar to Answer #2 in formality and legitimacy, details the relationship between multiples and squares using mathematical notations albeit with the abstraction of deictic references, using anaphoras to connect mathematical operations to resolution procedures. Therefore, different effects of meaning.

Unlike illustrations or accessories, the use of non-verbal elements (graphs, arrows, circles) was observed as *semiotic overflows* that extend beyond the formal language of mathematics and grammar, creating *metaimages*. Additionally, the use of the image as an argumentative, metaimagery, or referential instrument (such as arrows, lines, and circles) was noted. The flexibility of writing results transcends grammar to express mathematical reasoning with directional metaphors, markers, or structural diagrams.

Given that the BNCC and the PCN are guiding rather than prescriptive documents, it is possible to consider activities that stimulate the use discussed above, establishing a dialogue between the three skills: using different languages (EM13LGG103), translating reasoning into algebraic symbols (EM13MAT101), and critically evaluating the influence of technologies and social structures (EM13CHS403).

It is possible to promote logical reasoning and develop mathematical writing styles through points like these. Students' discursive engagement with numbers revisits the intrinsic relationship between reading and counting.

6 Outlook

This article proposed a more comprehensive approach to mathematics education, considering its technical dimensions and cultural and social implications. We discuss how the traditional view of teaching often marginalizes other cultures, perpetuating inequalities, especially in the Brazilian context, where the complexity of numerical rituals reinforces the division between experts and laypeople.

The scenario presented has an anthropological challenge: to relativize this division.

Although mathematics and Portuguese are still seen as distant areas, notable initiatives exist, such as the National Pact for Literacy at the Right Age, which took place between 2012 and 2018 (Brazil, 2014), the PCN, which share common objectives, including meaningful learning, the development of critical thinking, and problem solving.

Interdisciplinary collaboration could formulate more inclusive public policies not only in terms of people but also in terms of knowledge. Brazil's cultural diversity offers a unique setting for this collaboration, which can generate new methodologies for contemporary educational challenges.

Conflict of Interest

The authors declare that there are no conflicts of interest that could influence the results of the research presented in the article.

Data Availability Statement

The data produced, or collected, and analyzed in the article will be made available upon request to the author.

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