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Reflections on the concept of mathematical literacy: relational dynamics

Reflexiones sobre el concepto de letramiento matemática: dinámica relacional

Réflexions sur le concept de culture mathématique: dynamique relationnelle

Reflexões sobre o conceito de letramento matemático: a dinâmica relacional

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Abstract

This article, of a theoretical nature, presents the movement of concepts produced within the scope of Mathematics Education to refer to the term mathematical literacy. Literacy appears in Brazil when the term literate was no longer sufficient to characterize society's new reading and writing demands. From this perspective, based on Brazilian studies, we searched for different terms that directed us to others in the literature in the area, in which we highlight: *alfabetização matemática*, *numeramento*, *numeramentalização*, *literacia matemática*, *matemacia* e *materacia*. From these, we aim to identify the different concepts presented and the (in)existing relationships between them, paying attention to the diversity of perspectives that make up this plot. Thus, despite the lack of uniqueness in relation to the term mathematical literacy, we understand that there is a historical perspective of the construction and evolution of ideas about being mathematically literate. Furthermore, we point out the existence of a relational dynamic between the terms, as well as the categorization in the perspectives of individual acquisition, social practice and criticism, not in an isolated way, but with greater or lesser nuances in each of them.

Keywords: Mathematical literacy, Numeracy, Mathemacy, Matheracy, Relationship.

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Resumen

Este artículo, de carácter teórico, presenta el movimiento de conceptos producidos en el ámbito de la Educación Matemática para referirse al letramiento matemático. Los debates sobre letramiento se introdujeron en Brasil cuando el término alfabetizado ya no era suficiente para caracterizar las nuevas demandas de lectura y escritura de la sociedad. Desde esta perspectiva, a partir de estudios brasileños, buscamos diferentes términos que nos dirigieron a otros en la literatura del área, en los que destacamos: alfabetización matemática, numeramiento, numeramentalización, literacia matemática, matemacia y materacia. A partir de ellos, pretendemos identificar los diferentes conceptos presentados y las relaciones (in)existentes entre ellos, prestando atención a la diversidad de perspectivas que componen esta trama. Así, a pesar de la falta de unicidad en relación a lo que se entiende por letramiento matemático, entendemos que existe una perspectiva histórica de la construcción y evolución de las ideas sobre la competencia matemática. Además, señalamos la existencia de una dinámica relacional entre los términos, así como la categorización en las perspectivas de adquisición individual, práctica social y crítica, no de forma aislada, sino con mayores o menores matices en cada una de ellas.

Palabras clave: Alfabetización matemática, Numeramiento, Matemacia, Materacia, Relación.

Résumé

Cet article, de nature théorique, présente le mouvement des concepts produits dans le cadre de l'enseignement des mathématiques pour faire référence à la culture mathématique. Les discussions sur l'alphabétisation ont été introduites au Brésil lorsque le terme d'alphabétisé ne suffisait plus pour caractériser les nouvelles exigences de la société en matière de lecture et d'écriture. Dans cette perspective, sur la base d'études brésiliennes, nous avons recherché différents termes qui nous ont orientés vers d'autres dans la littérature dans le domaine, dans lesquels nous soulignons: culture mathématique, numératie, numératie, culture mathématique, mathématiques et materacia. À partir de ceux-ci, nous visons à identifier les différents concepts présentés et les relations (in)existantes entre eux, en prêtant attention à la diversité des perspectives qui composent cette intrigue. Ainsi, malgré le manque d'unicité par rapport à ce que l'on entend par culture mathématique, nous comprenons qu'il existe une perspective historique de la construction et de l'évolution des idées sur la culture mathématique. En outre, nous soulignons l'existence d'une dynamique relationnelle entre les termes, ainsi que la

catégorisation dans les perspectives d'acquisition individuelle, de pratique sociale et de critique, non pas de manière isolée, mais avec des nuances plus ou moins grandes dans chacun d'eux.

Mots-clés : Culture mathématique, Numératie, Mathématiques, Matératie, Relation.

Resumo

Este artigo, de natureza teórica, apresenta o movimento dos conceitos produzidos no âmbito da Educação Matemática para referir-se ao letramento matemático. As discussões acerca do letramento foram introduzidas no Brasil quando o termo alfabetizado não era mais suficiente para caracterizar as novas demandas de leitura e escrita da sociedade. Nessa perspectiva, a partir dos estudos brasileiros, buscamos diferentes termos que nos direcionaram a outros na literatura da área, em que destacamos: alfabetização matemática, numeramento, numeramentalização, literacia matemática, matemacia e materacia. A partir desses, temos por objetivo identificar os diferentes conceitos apresentados e as relações (in)existentes entre eles, atentando-nos à diversidade de perspectivas que compõe esse enredo. Assim, apesar da falta de unicidade em relação ao que se entende por letramento matemático, entendemos que há uma perspectiva histórica de construção e evolução de ideias sobre o ser letrado matematicamente. Ainda, sinalizamos a existência de uma dinâmica relacional entre os termos, bem como a categorização nas perspectivas da aquisição individual, prática social e crítica, não de forma estanque, mas com nuances maiores ou menores em cada uma delas.

Palavras-chave: Alfabetização matemática, Numeramento, Matemacia, Materacia, Relação.

Reflections on the concept of mathematical literacy: relational dynamics

The term[3] literacy in Brazil emerged in the 1980s when being literate began to require more skills than just reading and writing (Soares, 2019). Similarly, in mathematics, knowing numbers, counting, and calculating has become a rather restricted skill considering the needs of life.

Despite the numerous terms that exist to designate the specificities related to mathematical knowledge, we have chosen to use mathematical literacy because it manages to express all the variants, considering the breadth and complexity of mathematics. We also made this choice because we agree with Campetti & Dorneles (2022, p. 311) when they say that "the existence of different terms and their respective meanings does not necessarily imply weakness in the theory, but rather analytical fertility" and because we understand the different perspectives and the plurality of concepts.

Based on this analytical fertility, we have listed the following terms in this text: mathematical literacy (Danyluk, 2002), numeracy (Mendes, 2007; Fonseca, 2014; Toledo, 2004[4]), numerentalization (Pinho, 2013), mathematical literacy (Silveira, 2016), and mathemacy (Skovsmose, 2013) or matheracy (D'Ambrosio, 2004), found in Brazilian literature. By bringing up the term mathematical literacy, we aim to identify the different concepts presented and the (in)existing relationships between them, paying attention to the diversity of perspectives that make up this plot, with the hypothesis that there is a relational dynamic between the terms and concepts presented.

The study that gave rise to this text is characterized as a bibliographical study, of a theoretical nature, developed initially from readings on the subject of mathematical literacy. In this search, we came across the same and different terms with different meanings. As a result, we began a process of analysis of the terms and concepts created over time and built an organization around this collected material, understanding the dynamism that exists in the historical process.

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[3] Term derives from the Latin "terminus", which means end, limit. Grammatically, it is the representation of a word. We therefore use this word to highlight the grammatical issue. We understand that each term has an involved and representative concept and that, in some cases, the same terms will have different conceptualizations. On the other hand, the word concept, which comes from the Latin conceptus, means "thing conceived" or "formed in the mind". Thus, a concept can be expressed as an idea about something. As will be discussed in this article, the reader may understand that we are presenting ideas, i.e. concepts, and we therefore believe that this is a more appropriate term to use when referring to the definition or idea of something.

[4] Pinho (2013, p. 97) shows that the term numeracy has been used by various authors, such as: "Mendes (2001; 2007); Cabral (2007); Fonseca (2007; 2009); Faria (2007); Souza (2008); Drabik (2008); Ferreira (2009); Sotelo (2009); Sozzi (2010)".

Initially, we relied on Maia's thesis (2013) which investigated aspects related to the Mathematical Literacy process based on Brazilian studies in Mathematics Education demanded by government publications from 1996 to 2012. The author highlighted the ideas of Ole Skovsmose, Ubiratan D'Ambrosio, Ocsana Danyluk, and Maria da Conceição Ferreira Reis Fonseca, which were presented and discussed throughout the work.

We then turned to the dissertation by Gomes (2022), based on Critical Mathematics Education, which sought to investigate and learn about the main concepts related to Mathematical Literacy and Mathematical Literacy present in theses and dissertations produced in Brazil between 2009 and 2021. The research confirmed the presence of the four authors identified by Maia (2013), as well as Paulo Freire and Magda Soares, as important references in the area.

Campetti & Dorneles (2022, p. 310) also point out that, in the field of Mathematics Education, there is "the existence of a complex, plural - and perhaps confusing - set of terms used for the process of acquiring mathematical skills and competencies from early childhood to adulthood". Given this phenomenon, the authors seek to understand the reasons that explain the emergence and existence of triad *numeracia*, *numeralização* e *numeramento* and the possible conceptual differences between the terms.

While the literacy movement began in the 1980s, concern about numeracy or mathematical literacy in Brazil only began at the beginning of the 21st century. The work of Mendes (2001) and the first publication focusing on mathematics in the National Indicator of Functional Literacy - INAF, an index created in 2001 that measures the level of functional literacy in Brazil, stand out in this regard. To understand mathematical skills[5] of the Brazilian population, the results of the first INAF assessment relating to mathematics were compiled in 2002 and discussed in the book organized by Fonseca (2004). However, before this discussion, the perspective of mathematical literacy, intrinsic to the first years of schooling, had already been dealt with in the studies of Professor Ocsana Danyluk, in which we indicate the first ideas.

Mathematical literacy: the beginning of mathematical literacy?

At the end of the 20th century, as already explained, Brazil already had studies aimed at broadening the concepts of literacy and mathematical literacy. However, as Machado (2011) describes, progress is still needed.

[5] According to Fonseca (2004, p. 13), what was considered a mathematical skill was the "ability to mobilize knowledge associated with quantification, ordering, orientation, and their relationships, operations, and representations, when carrying out tasks or solving problem situations", concerning the tasks and situations that most of the Brazilian population faces daily.

> The carapace of being an arid subject, especially difficult, destined to be understood by only a few, does not fit Mother Tongue in general, but it does fit Mathematics perfectly. This, however, is not due to essential, endogenous reasons, but to inadequate approaches, so often used in mathematical content that, to the less aware, they seem to shape its features. This is what happens, for example, when mathematics is treated as a language in which the hypertrophy of the syntactic dimension unduly obscures the role of semantics, which is left in the background. (Machado, 2011, p. 22)

From this perspective, the author draws attention to the dimensions that can be worked on in mathematics. The importance of highlighting the semantics of mathematical language is to pay attention to the meaning and interpretation of mathematical components, whether through numbers, figures, sentences, statements, calculations, etc., beyond syntax.

Ocsana Danyluk (2002, p. 20) also understands that "mathematics is shown through language, which has a conventional arrangement of ideas that are expressed by signs with meanings". Danyluk was a pioneer in studies on mathematical literacy in her master's and doctoral research. In her 1989 dissertation (Danyluk, 1991), the author focused more on the aspect of reading in mathematical literacy, while the main concern in her 1998 thesis was to understand writing in this process.

Danyluk (2002, p. 61) focused on the issue of numbers based on a dialogue aimed at observing "what children know about numbers, where they recognize or see numbers, what numbers are used for in their conceptions, what numbers they know, whether they know how to count, when they count quantities, how long they count, what is in the room and what can be counted". From this perspective, the researcher seeks to understand the mathematical processes that are developed by children aged 4 and 5, considering how close they are to the literacy process, since she understands mathematical literacy "as a phenomenon that deals with understanding, interpreting and communicating the mathematical content taught at school, which is seen as the beginning of the construction of mathematical knowledge" (Danyluk, 2002, p. 20).

In this sense, despite looking at mathematical literacy in terms of learning "the mathematical language used in the first grades of schooling" (Danyluk, 2002, p. 14), in the course of her thesis, the author concluded that:

> the development of children's writing begins before they enter school and mathematical perceptions are assimilated differently from one individual to another. Children bring from their lived worlds information about mathematical aspects and knowledge characteristic of the socio-cultural context in which they live. (Danyluk, 2002, p. 231)

There is a dimension of individuality that is characterized by the singularities of the subject and the environment from which they come, while at the same time, mathematical

perceptions come from the socio-cultural context, which even implies different levels[6] of mathematical literacy, for example. When considering this precept, Mendes (2007, p. 12) emphasizes that Danyluk "restricts himself to an individual acquisition by the child of school mathematical knowledge codes" and indicates that his proposal highlights the social aspects of mathematical writing from the perspective of literacy studies.

We understand that, although Danyluk works from the perspective of literacy and even the appropriation of mathematical language from the schooling process in the early years, her thesis already suggested that there are "mathematical aspects" that are brought into the school environment from the social practices experienced in the context. This knowledge, according to the author, is part of and is re-signified with the appropriation of mathematical language, which is not explicit, but already shows a broadening in her proposal for mathematical literacy.

Numeracy: what is that term?

In addition to mathematical literacy, the emergence of other terms relating to mathematical literacy has been identified in different works. With its differences and similarities, numeracy is one of them. According to Campetti & Dorneles (2022), the term was conceived by Mendes (2001, 2007) in her master's thesis defended in 1995. In her dissertation, the author states that she decided to choose numeracy because of its analogy with the term literacy, based on the relationships drawn from the point of view of the plurality of social practices that exist around writing. For her, "numeracy can be thought of in the sense of the various practices in which different mathematics are produced, among which there are those that differ from school practices." (Mendes, 2007, p. 17).

The author refers to the autonomous and ideological models pointed out by Street[7] and points out the limited view of mathematical literacy presented by Danyluk (2002), inferring that it is restricted to an individual acquisition of school mathematical knowledge. For Mendes (2007, p. 18), school mathematics "to develop reasoning and abstraction skills, seems to implicitly point to the non-existence of such skills" so that it carries the autonomous model,

[6] When we talk about levels, we are not referring to an individual knowing, for example, up to the multiplication table of five and being at "level 2" of mathematical literacy. We don't have a reference point for the development of mathematical literacy, but we understand and agree with Cecco & Bernardi (2023) that individuals improve their level of knowledge and, automatically, of mathematical literacy, based on the social and cognitive practices they develop throughout their lives. This is a process that takes place in a variety of circumstances.

[7] For the author, the autonomous model deals with literacy in technical terms, independent of the social context, "an autonomous variable whose consequences for society and cognition are derived from its intrinsic nature" (Street, 1993, p. 5 *apud* Rojo, 2009, p. 99). The ideological model of literacy, on the other hand, understands literacy practices as being associated with the cultural and power structures existing in society.

based on its status as the holder of power[8], even indicating the dichotomy between knowing and not knowing mathematics.

Thinking of mathematics as a cultural product, Mendes (2007) emphasizes that it is linked to the ideological model of literacy. To make this point, the author uses examples from Lave's (1988) studies[9] on food preparation in a Weight Watchers class and shopping in a supermarket. According to her, these studies show that, despite the discontinuity between school mathematics and social practices, different practical experiences involve the context and not just the formal mathematical sphere. Mendes (2007) also provides an example based on the studies by Carraher *et al*.[10] on the numeracy practices of boys selling coconuts in Recife, emphasizing the resolution of problems in the context/everyday life, but not the resolution in school, "these same problems, presented in the way proposed by school practice, became something new, disconnected from the context" (Mendes, 2007, p. 21).

For the author, it is necessary to view numeracy from its cultural basis and observe how it is allocated practices, focusing on "the social aspects that involve mathematical writing" (Mendes, 2007, p. 14).

> In this way, numeracy cannot be seen as something singular: we can refer to various numeracies, in the same way that the idea of plurality has been attributed to literacy. Therefore, the plurality of numeracy is manifested by the diversity of social practices that exist around the notions of quantification, measurement, ordering, and classification in specific contexts, in which the various uses of these notions are closely linked to the socio-cultural values that permeate these practices (Mendes, 2007, p. 23).

The author also argues that it is difficult to think of numeracy practices that are not linked to literacy. According to her, "when we focus on numeracy, we can refer to the various social practices, present in society, which shape numeracy events in different contexts" (Mendes, 2007, p. 25).

Numeramento is also the term used by Toledo (2004), as a translation of English numeracy, which was adopted in her doctoral thesis[11]. The author highlights the existence of tasks that require "the application of integrated math and literacy skills". In this way, she defines numeracy as "a domain of skills that involves a subset of essential skills from both mathematics and literacy" (Toledo, 2004, p. 94).

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[8] "Similarly, perhaps even more emphatically, the number and the calculation are always presented as 'neutral truth', which could be identified, for example, in the phrase: 'the poll numbers confirm the voter's intention to vote'" (Mendes, 2007, p. 19).

[9] This refers to the studies presented in the book Cognition in Practice: Mind, mathematics, and Culture in Everyday Life, Cambridge University Press, 1988.

[10] The studies by Carraher *et al*. are presented in the book In Life Ten, in School Zero.

[11] When searching for the doctoral thesis, the online version was not found in the USP repository.

Although the author adopts the definition on an international basis[12], there is an approximation between her ideas and the perspective put forward by Mendes (2007) on practices involving numeracy and literacy. For Toledo (2004, p. 94), "being numerate involves the possession of some literacy skills and some mathematical skills and the ability to use them in combination, according to what is required in a given situation". An important point made by the author is about the levels of numeracy, similar to the degree of literacy proposed by Tfouni (2002), in which

> the level of numeracy needed by a single individual can change over time, depending on personal life circumstances, work transitions, and changes in reality or technology, whether in their personal history or social life. (Toledo, 2004, p. 95)

In other words, the level of numeracy is intrinsic to the context in which an individual finds. Furthermore, the appropriation or expansion of numeracy by the individual can bring about change, whether in the professional, personal, or social spheres.

Also based on Maia's study (2013), we noted that Maria da Conceição Ferreira Reis Fonseca was one of the authors cited. It is important to emphasize the organization of the book on mathematical skills (Fonseca, 2004), based on INAF 2002, which focused on mathematics. In this movement, the author is one of the references in Brazil from the perspective of studies on numeracy, especially in Youth and Adult Education[13]. Along these lines, Pinho (2013) pointed out Fonseca's differentiation of two possibilities for numeracy: i) as an analogy to literacy and ii) numeracy as an integral part of literacy.

Thus, in the first possibility, the parallelism between numeracy and literacy has been relevant

> in the quest to highlight both the concern with the teaching of formal Mathematics (Mathematical Literacy) and the efforts to understand and foster the cultural ways of "mathematizing" (Mathematical Literacy or Numeracy) in various fields of social life (even at school). (Fonseca, 2014)

[12] The author draws on UNESCO texts, and the American authors Cumming, Gal, and Ginsburg (1998), Gal (1993, 1994, 1999), and Johnston (1999).

[13] Maria da Conceição Ferreira Reis Fonseca coordinated UFMG's Youth and Adult Basic Education Program from 2005 to 2021. She is currently the leader of the Numeracy Studies Research Group (GEN) and vice-leader of the Interinstitutional Research Group on Mathematics Education and Society (GIPEMS). She was the coordinator of ANPEd's WG 18 - Education of Young People and Adults (2017-2019) and is currently the WG's representative on the Association's Scientific Committee. She is a consultant for the National Indicator of Functional Literacy - INAF. She carries out teaching, research, and extension work in the following fields: Mathematics Education, Youth and Adult Education, Literacy and Numeracy, and Rural Education. Available at http://lattes.cnpq.br/2605895454297792. Accessed on: 13 Dec. 2023.

The second possibility, by understanding numeracy as a dimension of literacy, "thus points to Mathematics Education as part of the efforts to expand the possibilities of critically reading the world". This is achieved by understanding the mathematical knowledge intrinsic to various social practices.

> In other words, since *Literacy* involves the conditions for the subject to meet the demands of a graphocentric society, to be literate, they will need to mobilize a variety of knowledge that is relevant to social life, including mathematical knowledge. **This is not only because of the recurrence of mathematical representations in the various texts that circulate in graphocentric societies but also because the ways of knowing, explaining, organizing, arguing, deciding, and appreciating in these societies are based very strongly on quantitative, metric or classificatory criteria, which make up what we call mathematical knowledge**. So even a beginner reader will come across texts in which prices, measurements, quantities, graphs, or tables appear. These are supermarket promotion leaflets or snack bar price lists, product labels, medical records for children or adults, newspaper or TV articles publicizing phenomena and research, and many other texts that should already appear in literacy classes. They contain numbers, tables, graphs, and diagrams - which a reader also needs to learn to read, because it is based on this reading that many decisions are made, such as whether or not to consume a product, choosing what and where to buy, changing a health treatment, choosing a candidate. The concern to understand the roles of this quantified information or the effects of meaning they confer on texts is what makes us understand *Numeracy* as a dimension of *Literacy*. (Fonseca, 2014, *emphasis added*).

In other words, the author initially identifies numeracy from the literacy proposed by Soares, although this term has been rethought over time... There is a recognition of the need to be numbered to be literate, as being a necessary dimension for a subject to be literate or not.

Other conceptualizations of mathematical literacy

Still searching for terms and conceptions, we find numericalization in Pinho's thesis (2013, p. 69). The author considers "numericalization based on the establishment of relationships between the notions of power and forms of government in Foucault", taking into account how individuals conduct and know the use of numbers and their forms of registration.

> In an analogy to governmentality, Bello (2012) mentions that numericization can also be treated as numeramentality when referring to contemporary normativity based on quantification, measurement, the use and recording of numbers in their capacity for subjectivization, and the constitution of subject forms. The neologism mumeramentalité, coined by the researcher, expresses the processes of governmentalization of government strategies and can be translated into French as numeramentalité, in an analogous way to the Foucauldian term governamentalité (Pinho, 2013, p. 70).

The author's perspective raises the issue of the political processes underlying the development of social relations and practices, whether or not they involve schools. In other words, it refers to the convergences between government activities and the "normative practices of numbering, measuring, quantifying, serializing, which produce ways of guiding conduct in institutional spheres, such as schools, health care, and inspection bodies, for example" (Pinho, 2013, p. 76).

In the construction of her thesis, the author also brings up numeralization, a term used by Nunes and Bryant[14] (1997 *apud* Pinho, 2013, p. 95), as a process in which the "constant change in social practices generates varied demands that often require multiple mathematical skills, in which mathematical thinking procedures and tools must be adapted". Furthermore, Nunes & Bryant (*apud* Pinho, 2013, p. 31) state that "'Being numerate means thinking mathematically about situations [...]', and not simply using operative techniques in math classes".

When thinking about the relationship between school and the mathematics taught in this space, Pinho (2013, p. 106) points out that "the notion of numericalization allows us to understand how mathematical practices gain an instrumental dimension in the curriculum, investing in the production of subjects who mobilize these instruments in their daily activities, in school and outside of it". In addition, the author states that numericalization "seeks to understand the use of numbers, the relationships between them and their registers in contemporary practices, also as a neoliberal governmental technology for guiding our conduct" (Pinho, 2013, p. 107). In her view, this is a different process from numeralization, which focuses on the socio-cognitive construction of mathematical objects, and numeralization, which considers the social impacts of mathematical writing on society.

In this search for terms that help us "think" about a definition for the concept of mathematical literacy, Silveira (2016), in her doctoral thesis, uses mathematical literacy. The

[14] The reference brought up by Pinho is from the book Crianças fazendo matemática. Porto Alegre: Artes Médicas, 1997. According to Campetti & Dorneles (2022, p. 315), since Nunes and Bryant (1997), "the use of the term numeracy in research has not received enough attention to be the main subject of a dissertation, thesis or article published in a journal". In addition, the authors identified that numeralization and numeracy are used with very close meanings, sometimes coinciding, with the major distinction being that the first is related more to the early childhood public while the other is aimed at the general public.

author articulated it with journalistic practice, to train higher education professionals. She understands mathematical literacy according to the Organization for Economic Cooperation and Development (OECD) as the ability to "formulate, use and interpret mathematics in various contexts" (Silveira, 2016, p. 17) and also points out the use of terms such as numeracy and quantitative literacy[15]. With a more focused look at the mathematics of future journalists, for the author, mathematical literacy "contextualizes mathematical action, contrasting with the curriculum that historically focused on school knowledge and compartmentalized it, making it difficult to apply in the real world", however, she warns that there is no consensual definition of it.

Regarding mathematical literacy, Gonçalves (2005, p. 10, emphasis added) conceptualizes "temporarily" as:

> the condition from which an individual understands and reflexively elaborates oral and written texts containing mathematical concepts and transcends this understanding to a social and political sphere. When we mention mathematical concepts we are including the mathematical language that may or may not be accompanying such conceptualization.

From this angle, before defining a concept, Gonçalves (2005) points out a set of parameters that should be taken into account when conceptualizing mathematical literacy. The author mentions the micro and macro aspects, as well as the complexity that can be involved when talking about mathematical literacy.

This complexity was also pointed out by Fonseca (2004, p. 22) when she exposed the numerous terms used to refer to mathematical literacy in the INAF book. For her, an "analysis of the success rate, question by question, reveals that the interviewees' greatest difficulty is not in 'doing math', but in solving problems", since, in general, they don't follow a single way of solving problems.

[15] According to Silveira (2016), the term numeracy was coined in a British report published in 1959 and its concept was expanded in 1982 into two attributes: familiarity with numbers and the ability to use mathematical skills to meet everyday needs, and the ability to understand mathematical information presented in the form of graphs and tables. The term quantitative literacy, on the other hand, is more present in studies by North American authors. Based on my reading and participation in the Literacies for the 21st Century Congress in Portugal, I note that Portuguese authors use the terms mathematical and quantitative literacy.

In this sense, in the questions raised by the book, we present the example of Toledo (2004), who presented his study referring to 21 subjects among the two thousand interviewed in the INAF with little or no schooling who showed a high level of mathematical literacy (level 2 or 3). In contrast, Carvalho's study (2004) analyzed 21 subjects who, having completed secondary school, only had a mathematical literacy index of 1 on the INAF. These studies make us think along the lines of Fonseca (2004) about knowing how to do math, but not knowing how to solve problems: what is the concept involved? What numeracy or mathematical literacy is not being worked on? Also, in what way is this mathematics being worked on in such a way that it does not foster the development of a mathematical literacy that is minimally desired for everyday issues, such as the ability to solve problems, make decisions, and enable progress?

Mathematical literacy from a critical perspective

Contributing to the question that closed the previous section of this text, matheracy, and mathemacy, proposed by D'Ambrosio and Skovsmose, help us to understand a critical take on the terms, as well as being important for understanding the relational dynamics surrounding mathematical literacy. Let's start with what D'Ambrosio (2004) proposes:

> For example, what does it matter, from the point of view of the individual in society, to conclude that young Brazilians reach the age of 12 not knowing how to correctly conjugate the verb "to sit"? Perhaps this young person, even without knowing how to conjugate, has understood what it means, socially, to be sitting. But perhaps they know how to conjugate and aren't capable of evaluating everything that goes into the act of sitting. Likewise, we could ask what it matters if, at that age, he can extract the square root of 12764? Or to add up 5/39 + 7/65? What does this have to do with the satisfaction and expansion of his potential as an individual and his full exercise of citizenship? (D'Ambrosio, 2004, p. 32)

The questions raised by the author, whether about the conjugation of the verb to sit or the extraction of the square root of a number, make us reflect on education and, especially, the teaching of mathematics. Anchored in a Mathematics Education for Peace, with respect and solidarity for humans, the author defends education as "a strategy to stimulate individual and collective development generated by cultural groups, [...] respecting their cultural roots, and to advance in the satisfaction of survival and transcendence needs" (D'Ambrosio, 2012, p. 8).

In exposing the organizational dynamics of school curricula, based on the American model known as the "three R's: Reading, Writing and Arithmetic", D'Ambrosio (2021, p. 58) stated that for the 21st century "reading, writing and counting are insufficient for full citizenship in the new century". With this in mind, the author proposes a curriculum based on the trivium of literacy, matheracy, and technocracy, as an "educational response to the expectations of eliminating inequity and violations of human dignity, the first step towards social justice". When considering the trivium, he argues that "the complexity of modern society demands that schools dedicate themselves, with equal priority, to providing students with analytical and technological tools, which I call matheracy and technocracy, respectively." (D'Ambrosio, 2004, p. 36).

According to the author, none of the words were dictionaries, and literacy was/is derived from a report published in Portugal that defined it "as the ability to process written information in everyday life, which includes writing, reading and calculating", recalling that it originates from the English literacy as already pointed out by Soares (2019). As for matheracy, "the neologism matheracy was introduced in the 1980s by Professor Tadasu Kawaguchi, one of Japan's most prominent mathematics educators" (D'Ambrosio, 2021, p. 58) and defines it as "the ability to interpret and handle signs and codes and to propose and use models in everyday life" (D'Ambrosio, 2021, p. 58).

In a way, criticizing INAF, as well as other standardized assessments, D'Ambrosio (2004) points to literacy and counting as insufficient for a citizen in the context of the various practices he or she experiences.

> In other words, dealing with numbers, as they appear in prices and measures, timetables and calendars, and even being able to carry out some elementary operations, is insufficient for citizens. It is misleading to believe that mere literacy leads to the full exercise of citizenship (D'Ambrosio, 2004, p. 36).

In other words, mathematical literacy, based on the acquisition of some basic skills, although necessary and important for survival, is insufficient for taking a stand on certain issues. D'Ambrosio (2002, p. 11) emphasizes the importance of not only the process of social

acquisition of mathematical concepts but also "the process of acquiring this codification, which is the first step in matheracy".

Thus, "shallow" mathematical literacy is not enough to meet the different demands of the complex society we live in. In this context, a certain degree or level of mathematical literacy is necessary for us to be minimally prepared to act as citizens. While some dimensions have been made easier, to access them we need to be connected and mathematically, digitally, and critically literate.

Skovsmose (2013, p. 66), from the perspective of Critical Mathematics Education (CME), points out that Gramsci "indicated that literacy is a double-edged sword", which is a necessary condition for people to be informed and to be able to take part in basic work processes, as well as being able to be manipulated with the aim of *empowerment*[16]. In the same vein, the author wonders whether mathematical literacy[17] can also be this double-edged sword, after all, "literacy is not just a competence relating to the ability to read and write, a skill that can be both tested and controlled; it also has a critical dimension" (Skovsmose, 2013, p. 66).

When we consider the interpretation proposed by D'Ambrosio about the need for mathematical knowledge in the face of society's high demands, using it critically is an important skill in the face of existing possibilities. After all, knowing mathematics, in addition to basic skills, with the potential for decision-making, becomes important in the face of the demands we face daily, such as choosing a certain product, using money, buying or selling a property.

Skovsmose has different concerns about the research approach:

> One of them is the development of *matheracy*, seen as a competence similar to *literacy* as characterized by Freire. Matheracy refers not only to mathematical skills but also to the competence to interpret and act in a social and political situation structured by mathematics. Critical mathematics education includes an interest in the development of mathematics education as a support for democracy, implying that the micro-societies of mathematics classrooms should also show aspects of democracy (Skovsmose, 2008, p. 16, emphasis added).

[16] *Empowerment* is the word used by Skovsmose (2014, p. 66) with the meaning of empowering, giving power to, activating creative potentiality, and developing creative potentiality. The term can be translated as empowerment.
[17] Skovsmose (2013, p. 67) initially understands mathematical literacy as "an ability to calculate and use formal techniques", and later presents a different concept. As this is a translation, the term originally used by Skovsmose was *mathemacy* with the same meaning as the term *matheracy* (used by D'Ambrosio). However, the translator chose to translate it as mathematical literacy and we have kept the term at this point in the text.

Thinking about Critical Mathematics Education, for Skovsmose, involves reflecting on mathematics as its role in society, the development of mathemacy (or matheracy) as a competence linked to democracy, as well as empowerment or disempowerment. Kleiman (1995, p. 8) pointed out that "studies on literacy today, following the path traced by Paulo Freire more than thirty years ago, emphasize the empowering effect of literacy". In other words, just as (mathematical) literacy can promote the empowerment of individuals and their critical participation in society, it can also be an element of alienation (Tfouni, 2002).

> In particular, we must be able to understand what mathematics does for society. This provides (some) meaning to the formulation: mathematical literacy [matemacia/materacia], as a radical construct, must be rooted in a spirit of critique and a project of possibilities that enables people to participate in understanding and transforming their society. (Skovsmose, 2013, p. 95)

Therefore, for Skovsmose (2013, p. 67), mathematics "would become a prerequisite for social and cultural emancipation". The defense of working with mathematics as a project of possibilities that enables subjects to actively participate in the society in which they are inserted is part of a conception that considers mathematics beyond a topic to be taught and learned; it is necessary to reflect on mathematics itself (Skovsmose, 2008).

According to Mendes (2007, p. 12), the concept of mathemacy proposed by Skovsmose (2013), linked to a critical social view of Mathematics Education, "presents a view of mathematical literacy that is different from that which focuses only on individual acquisitions of codes, coming closer to the discussion about the impact of mathematical writing on society". From this perspective, aware that not all the terms and concepts used to qualify or approach mathematical literacy have been included in this text, we have organized, using the Canva program[18], an organizational chart of the terms relating to mathematical literacy. It shows the authors or works that support them and the relationships between them.

Relational dynamics: a construction based on terms referring to mathematical literacy

[18] Canva is a graphic design platform that allows you to create social media graphics, presentations, infographics, posters, and other visual content. Available at: https://www.canva.com/

Based on the emerging concepts raised in this article, we have constructed a representation concerning the authors, pointing out the similarities between the meanings attributed to them, as well as the differences that exist when they deal with the same term.

Based on the epistemological strands and the meanings attributed by each author, we present the terms and concepts that drive mathematical literacy, and we chose to use Canva for this construction. We took care to represent, based on our studies, the structuring of the terms, the authors, and the references that helped in the conceptualization proposed by each author.

As we can see, the figure below shows the terms that have been highlighted throughout the text (in dark green), and the relationships between them, including their differentiations. We can see the approximations between mathematics and matheracy proposed by Skovsmose and D'Ambrosio from a critical perspective, based on Giroux's studies and Freire's literacy.

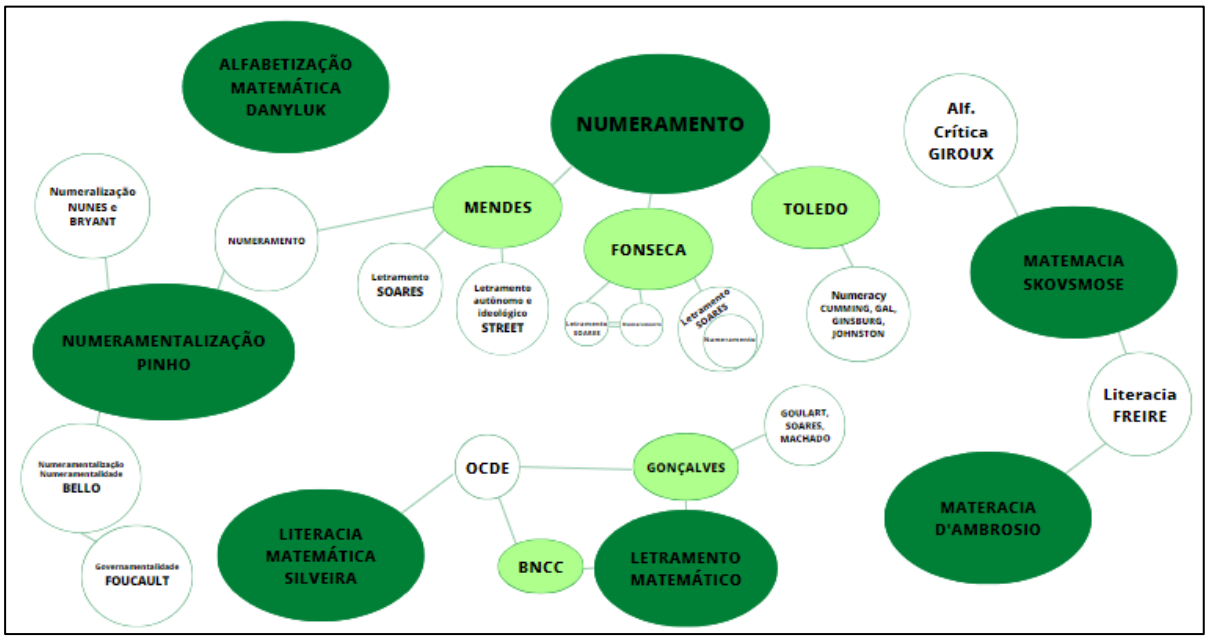

Figure 1.

Relational dynamics of terms referring to mathematical literacy and its aspects, prepared by the authors, 2023

Mathematical literacy, as proposed by Danyluk (2002), is initially based on the concept of an individual acquisition of mathematical concepts. However, in the course of her studies, the author herself identifies the influence that the socio-cultural context has on this acquisition. She

approaches mathematical literacy through the lens of phenomenology and stresses the need to pay attention to the social and political issues involved in the act of literacy. In addition, Danyluk (2002) draws on research into the act of writing that helps us to think about mathematical literacy. The ideas of Emilia Ferreiro and Alexander Luria are highlighted, but without emphasizing the terms used by these authors.

> Therefore, Mathematical Literacy is the work that leads to an understanding of the mathematical content taught at school, which is considered to be the starting point for mastering mathematics. The relevance of this content must emerge from a study carried out in the culture where the school is located. It is necessary to consider the knowledge of the person coming to school as part of the roots of the mathematical thinking of the community where that person lives, as well as taking into account mathematics, understood as a body of scientific knowledge, built by humanity and relevant to that culture. (Danyluk, 1991, p. 111-112)

Mathematical literacy, on the other hand, is articulated by Silveira (2016) from the point of view of an international organization and is characterized, above all, by a contextualization of mathematics, combining the world of school and the real world. Numeracy, a term used by Fonseca (2004), Mendes (2007), and Toledo (2004) in a more social context, is considered from different meanings, but with a certain harmony. About the term numericalization, Pinho (2013) uses it based on the definition proposed by Bello and based on Foucault, and also presents numerization (based on Nunes and Bryant) and numeracy (based on Mendes). For the author, the concept of literacy and literacy is intrinsic to this differentiation. According to her, numeracy "focuses on the influence of the relationship between mathematics and society on the process of individual development - becoming numerate" from a perspective of acquiring individual skills, while numeracy proposes a shift away from individual acquisition "expanding it to the impacts of the different uses and functions of mathematical knowledge in various social practices" (Pinho, 2013, p. 100).

Seeking to get closer to numeracy, Figure 2 shows it and, as can be seen, the references used to conceptualize the term by each author, a process that is also permeated by differences.

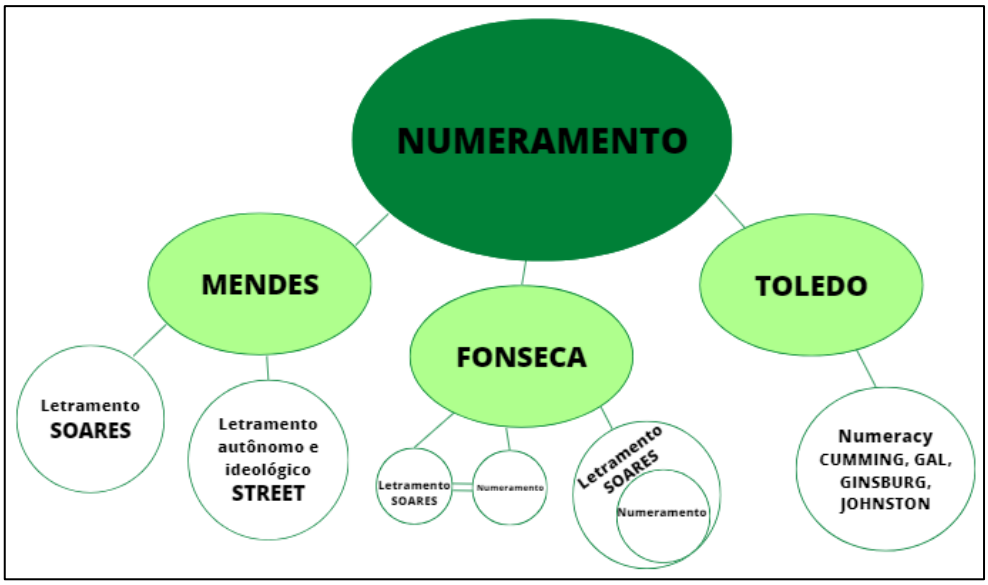

Figure 2.

A special focus on Numeracy, prepared by the authors, 2023

As shown in Figure 2, it is clear that each of the authors analyzed here relied on different references to construct and defend the concept attributed to numeracy, which has already been explained above. Both Mendes (2007) and Fonseca (2014) rely on literacy, a term derived from Magda Soares' studies developed in the mid-1990s. Mendes (2007) points to the ideological and autonomous models proposed by Street, while Fonseca (2014) explains a process of understanding the two dimensions, also based on Soares, and currently understands numeracy as a dimension of literacy. Toledo (2004) is the author who differs the most in her use of numeracy, as she uses international bases to define the concept.

Figure 1 shows the diversity of perspectives that make up the plot surrounding the definition or conceptualization of the term mathematical literacy, as already evidenced by Fonseca (2004), Mendes (2007), and Campetti & Dorneles (2022). Faced with the complex, globalized, and unequal society in which we live, it becomes a difficult task to understand and promote mathematical literacy in schools and society as a whole, since the very "discontinuity of nomenclature in official documents weakens the very use of the term and, as a result, its concept" (Cecco & Bernardi, 2022, p. 97).

When mathematical literacy was emphasized in the National Common Core Curriculum (BNCC) in 2017, it highlighted the need and concern for its development. Based on the Programme for International Student Assessment (PISA), developed by the OECD, the BNCC understands mathematical literacy as the individual ability to formulate, use, and interpret mathematics in a variety of contexts, which "ensures that students recognize that mathematical knowledge is fundamental to understanding and acting in the world" (Mec, 2018, p. 266).

In this movement, we rely on an expanded view of the studies by Danyluk (2002), the proposals by Soares (2019), and Fonseca (2004). Above all, as a critical dimension, we base ourselves on the ideas of Freire, D'Ambrosio, and Skovsmose, when thinking about a teaching and learning process that is for everyone and throughout life. Figure 3 represents this movement, of mathematical literacy that is not reduced to rote learning and the mechanization of repetition of exercises and procedures, but rather aimed at learning that promotes the development of mathematical knowledge, based on social practices and that leads to empowerment, stimulating reflection and criticality in students.

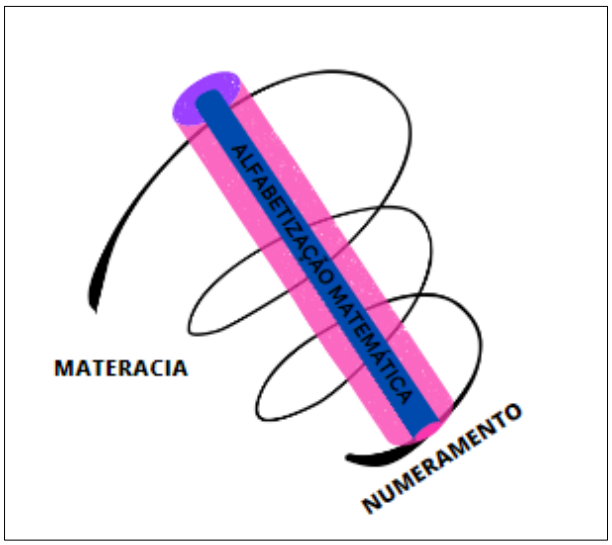

Figure 3.

Mathematical Literacy Movement, prepared by the authors, 2023

When talking about lifelong learning and teaching that enables empowerment, Grossi & Fonseca (2023, p. 402) present us with the appropriation of numeracy by elderly women in

the process of literacy during a trip to the market. In this work, they highlight the mobilization of "coding systems, symbols and meanings that structure, parameterize and are used in the representation of expiry dates". They also showed the knowledge they had acquired throughout their lives, as well as their desires and the conditions of the female aging process itself.

> In other words, pedagogical work would focus on mathematical knowledge (including ideas, representations, procedures, and criteria) as cultural ways of understanding the world, organizing, narrating, and evaluating the relationships we establish with people, things, and events. This knowledge is relevant insofar as it helps us to make sense of the texts we read and write, to take ownership of the literacy practices that are established in various instances of social life, identify their intentions and resources, and also being able to create strategies of adaptation or resistance - and even transgression - to the modes of organization and production of a society governed by the written word. (Fonseca, 2014)

Thus, we corroborate Fonseca's (2014) view of numeracy as a dimension of literacy, considering the need for individuals to read the mathematics that is inherent in the social practices of the context they encounter, in a conception that points "to Mathematics Education as part of the efforts to expand the possibilities of critical reading of the world" (Fonseca, 2014). In other words, the concept adopted by Fonseca is close to the mathematical literacy and/or matheracy emphasized by D'Ambrosio and Skovsmose, while the development of mathematical literacy must be rooted in criticality, in a way that empowers subjects, contributing to daily decision-making and the transformation of their social reality.

Final considerations

The efforts we have made so far to structure the different meanings, conceptualizations, and terms that are similarly used to talk about mathematical literacy have not been in vain. Along the way, we have deepened our knowledge of the perspectives adopted by the literature and can categorize them based on individual acquisition, social practice, and critical perspective. This does not mean that each term is locked into a single category, but certainly what the authors conceptualize has dimensions that can be identified with greater or lesser variation in each of them.

Just as Campetti & Dorneles (2022) identified that the main distinction between numeracy and numeracy is that they are related to different audiences, the terms mathematical

literacy, numeracy, and matheracy are also related to more specific moments in human life. Mathematical literacy is addressed and understood by Danyluk (1991, 2002) in the early stages of the schooling process, while numeracy is worked on, above all, in the literacy process of young people, adults, and the elderly, initially being discussed in a very characteristic way based on the appropriation of numeracy practices involving these and other individuals. Mathematics, on the other hand, with a critical bias, represents a lifelong attitude, combining the individual acquisition of mathematical knowledge and the social practices experienced.

We point out that (mathematical) literacy is only concerned with coding and decoding letters, signs, symbols and calculating basic operations, the "three R's" curriculum (D'Ambrosio, 2021) and the back-to-basics approach to reading as a utilitarian approach that "sees literacy as something that meets the basic reading requirements of an industrialized society" (Freire & Macedo, 2021, p. 178) are not enough for the complex demands of today's society. These require higher levels of (mathematical) literacy daily.

Similarly to the cultural policy perspective, literacy can be seen as a set of practices that act to empower or disempower (Freire & Macedo, 2021). Therefore, the development of mathematical literacy, from a critical perspective, can also contribute to empowerment or disempowerment (Skosmose, 2014).

Even so, we agree with D'Ambrosio (2012) when he states that it only makes sense to insist on education and, especially, Mathematics Education if it is possible to achieve full development from it. This is permeated and guaranteed when "we achieve a better quality of life and greater human dignity, which essentially depends on an individual's respect for other individuals and the conduct of our relationships with the environment" (D'Ambrosio, 2012, p. 9-10).

Discussions around mathematical literacy have been further emphasized in the Brazilian context since the BNCC. The lack of uniqueness of the term highlights the existing complexities, while at the same time highlighting a historical perspective of the construction and evolution of ideas about being mathematically literate, or even the understanding that we are "mathematized bodies" (Freire, 1996).

By way of conclusion, but without ending the debate, we present a historical construction of mathematical literacy and its variants. In addition to the categories (individual acquisition, social, and critical practice), we have identified a relational dynamic between the concepts attributed by the authors, in which the categories become nuances of the process, in which the terms gradually gain potent meanings.

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