ISSN 1983-3156
Qualis A1
http://dx.doi.org/10.23925/1983-3156.2023v25i1p25-46

Discussing the Emergence of Mathematical Modelling in Mathematics Education

Problematizando a emergência da modelagem matemática na educação matemática

Cuestionando el surgimiento del modelado matemático en la educación matemática

Interroger l'émergence de la modélisation mathématique dans l'enseignement des mathématiques

Maria Carolina Machado Magnus [1]
Universidade Federal de Santa Catarina
Doutorado em Educação
ORCID iD 0000-0002-2834-9293

Ademir Donizeti Caldeira [2]
Universidade Federal de São Carlos
Doutorado em Educação
ORCID iD 0000-0003-0290-9851

Claudia Glavam Duarte[3]
Universidade Federal do Rio Grande do Sul
Doutorado em Educação
ORCID iD 0000-0002-8608-5855

Resumo

O presente artigo tem por objetivo problematizar as condições de possibilidade para que o discurso da Modelagem Matemática emergisse na Educação Matemática brasileira. Para isso, lançamos mão de aportes teórico-metodológicos vinculados às teorizações do filósofo Michel Foucault. O material analítico abrange teses e dissertações defendidas no Brasil no período entre os anos de 1976 e 1999, as quais tematizaram a Modelagem Matemática na Educação Matemática. A análise desses estudos evidenciou que a emergência do discurso da Modelagem ocorre em meio a uma crise no ensino de Matemática. Essa crise foi problematizada, no presente artigo, a partir do seguinte enunciado: "***a matemática é distante da realidade***". Pudemos concluir que, o Movimento da Matemática Moderna possibilitou a emergência da Modelagem Matemática na Educaçãoo Matemática. Pois, ela proporcionaria um trabalho interdisciplinar – minimizando o distanciamento entre a Matemática e a realidade – e, logo, traria significado

[1] maria.magnus87@gmail.com
[2] mirocaldeira@gmail.com
[3] claudiaglavam@hotmail.com

para o ensino e a aprendizagem de Matemática – amenizando as dificuldades dos alunos pela sua aprendizagem.

Palavras-chave: Modelagem Matemática, Realidade, Aprendizagem, Ensino, Emergência.

Abstract

The purpose of this article is to discuss the conditions that would make it possible for the Mathematical Modelling argument to emerge in Brazilian Mathematics Education. To this end, we have used theoretical and methodological resources linked to theories by the philosopher Michel Foucault. The analytical material covers master's and doctoral theses developed in Brazil between the years 1976 and 1999, which have conceptualized Mathematical Modeling in Mathematics Education. The analysis of such studies has made it evident that the concept of Mathematical Modeling occurs during a crisis in Mathematics teaching, which has been discussed here from the following statement: "**Mathematics is distant from reality**". We could conclude that the Modern Mathematics Movement made the emergence of Mathematical Modeling possible in Mathematics Education. The reason for that is that it would provide for interdisciplinary work - minimizing the distance between Mathematics and reality - thus, it would bring meaning to the teaching and learning of Mathematics - mitigating the difficulties students go through to learn it.

Keywords*:* Mathematical modelling, Reality, Learning, Teaching, Emergence.

Resumen

Este artículo tiene como objetivo problematizar las condiciones de posibilidad para que el discurso de la Modelación Matemática emerja en la Educación Matemática Brasileña. Para ello, nos valemos de aportes teórico-metodológicos vinculados a las teorías del filósofo Michel Foucault. El material analítico abarca tesis y disertaciones defendidas en Brasil en el período comprendido entre 1976 y 1999, que tematizaron la Modelación Matemática en la Educación Matemática. El análisis de estos estudios mostró que el surgimiento del discurso de la Modelización ocurre en medio de una crisis en la enseñanza de las Matemáticas. Esta crisis fue problematizada, en este artículo, a partir de la siguiente afirmación: "las matemáticas están lejos de la realidad". Podríamos concluir que el Movimiento de las Matemáticas Modernas hizo posible el surgimiento del Modelado Matemático en la Educación Matemática. Pues, proporcionaría un trabajo interdisciplinario -minimizando la distancia entre las Matemáticas y la realidad- y, por tanto, daría sentido a la enseñanza y aprendizaje de las Matemáticas - aliviando las dificultades de los estudiantes para su aprendizaje.

Palabras clave: Modelo Matemático, Realidad, Aprendiendo, Enseñando, Emergencia.

Résumé

Cet article vise à problématiser les conditions de possibilité d'émergence du discours de la modélisation mathématique dans l'enseignement des mathématiques au Brésil. Pour cela, nous nous appuyons sur des apports méthodologiques théoriques liés aux théorisations du philosophe Michel Foucault. Le matériel analytique couvre les thèses et mémoires soutenus au Brésil entre 1976 et 1999, qui traitaient de la modélisation mathématique dans l'enseignement des mathématiques. L'analyse de ces études a montré que l'émergence du discours de Modélisation se produit en pleine crise de l'enseignement des Mathématiques. Cette crise a été problématisée dans cet article, à partir de l'énoncé suivant : “les mathématiques sont loin de la réalité”. Nous pourrions conclure que le mouvement des mathématiques modernes a permis l'émergence de la modélisation mathématique dans l'enseignement des mathématiques. Eh bien, cela fournirait un travail interdisciplinaire – minimisant la distance entre les mathématiques et la réalité – et, par conséquent, donnerait du sens à l'enseignement et à l'apprentissage des mathématiques – atténuant les difficultés d'apprentissage des élèves.

Mots clés: Modélisation Mathématique, Réalité, Apprentissage, Enseignement, Urgence.

Problematizing the Emergence of Mathematical Modeling in Mathematics Education

Something always emerges
in a given state of forces
(Foucault, 2011, p. 23, our translation)[4].

"Why teach Mathematics from Mathematical Modeling?", "What state of forces is going on there?", "Why is the relationship between Mathematics and other areas of knowledge started to be discussed in Mathematics Education?", "Why does Modeling become a 'subject' among mathematics educators?", "Why work with Modeling?". There are so many whys...

Indeed, those "whys" set us in motion to think, reflect, problematize, and investigate the conditions of possibility for the discourse of Mathematical Modeling to emerge in Brazilian Mathematics Education. In the wake of this problematization, we question: Why does this discourse gain visibility among researchers and professors at a given historical moment? What clashes of forces enabled the emergence of Modeling? It is worth mentioning that "discourses emerge and are constructed precisely to the extent that they also break with a certain order of knowledge" (Fonseca, 2009, p. 1). Therefore, we also question: What knowledge was/is broken by this discourse? What order does/did the emergence of Modeling intend to establish? To destabilize the firm ground of Modeling and problematize our concerns, we will return to the origin of this discourse. Therefore, all these questions generate what we call the problematic field of our research.

'Provenance' is the term used by Foucault –and Nietzsche– to contrast his historical research with research on origin. Origin research seeks, from the present, to return to the past in search of an initial essence, as if, in the act of returning to the past, they could find the "raw" and immobile form waiting to be "discovered" and polished. Those surveys seem to "believe that things at the beginning were in a state of perfection; that they came out bright from the creator's hands, or in the shadowless light of the first morning" (Foucault, 2011, p. 18). Reciprocally, Foucault (2013, p. 152) tells us that he is not "looking for that first solemn moment from which, for example, all Western mathematics was possible. I do not return to Euclid or Pythagoras. It is always relative beginnings that I look for".

According to Veiga-Neto (2007), provenance, or ancestry, can be understood as origin in its weak sense, i.e., as a point back in time, a place – or rather, a non-place – of confrontation, of combat of forces. Provenance research "shakes what was perceived immovable, fragments

[4] The citations in the text are free translations based on the publications in Portuguese.

what was thought to be united; shows the heterogeneity of what was imagined in conformity with itself" (Foucault, 2011, p. 21).

We understand, therefore, that going back to the past is not to seek a brute form, its original essence; it is, instead, to ruin the "essentialities, denying the existence of an in-itself of things, showing them as fabrications from dispersed elements " (Albuquerque Júnior, 2008, p. 99); it is to show the struggle of forces, to agitate what is perceived as immobile; it is looking for quicksands, pieces of shards that were marginalized by traditional history. It is not "finding definitive versions of the facts, but dismantling those versions taken as true, making others possible, freeing the words and things that come to us from the past from their museological imprisonment" (Albuquerque Júnior, 2008, p. 101).

When looking at the past, care must be taken not to place "a current concept, idea, or understanding. [...]. One should not try to understand the past based on categories of the present. [...] the present can never be the court of the past" (Veiga-Neto, 2007, p. 60-61).

This return to the past, to its provenance, enabled us to map the conditions of possibility for the emergence of this discourse. Emergence is the entry of forces into the scene, the exit from the wings to the theater (Foucault, 2011), I; is the coming to the fore, the point of emergence of discourse in the past. Still, "no one is therefore responsible for an emergence; no one can glorify him/herself by it; it is always produced in the interstice" (Foucault, 2011, p. 24).

To give visibility to our research, we organized the article as follows: this introduction, where we present the problematic field of investigation; in the section entitled "theoretical-methodological tools: the analytical resource", we describe the analytical resources; in the section "theoretical-methodological tools: the statement" we approach the concept of statement based on Foucault; still on the methodological aspects, we have "theoretical-methodological tools: the perspectives", where we discuss the way we analyze the analytical resources; to conclude, we present the analysis of the data in the section entitled "mathematics is far from reality" and in the section "to conclude" we offer a summary of the engendered analysis.

Theoretical-methodological tools: the analytical resource

To mobilize our thinking and compose the analytical resource, we selected master's and doctoral theses focused on Mathematical Modeling and defended in Brazil from 1976-1999. This period was chosen because we believe that was the emergence and institution phase of Modeling as a discourse taken as true (MAGNUS, 2018). We chose those works because, in the phase mentioned, the main place for discussion and circulation of this discourse was through scientific production, materialized in masters' degree and doctoral theses.

Table 1.

Selected resources (authors' own, 2022)

Title	Author	Year	Level
Modelos na aprendizagem da matemática [Models in mathematics learning]	Wilmer	1976	Master's thesis
Estratégia combinada de módulos instrucionais e modelos matemáticos interdisciplinares para ensino-aprendizagem de matemática a nível de segundo grau [Combined strategy of instructional modules and interdisciplinary mathematical templates for teaching and learning mathematics at the high school level]	Sánchez	1979	Master's thesis
Modelos matemáticos no ensino da matemática [Mathematical models in mathematics teaching]	Müller	1986	Master's thesis
Modelagem Matemática: uma metodologia alternativa para o ensino de matemática na 5ª série **[Mathematical modeling: an alternative methodology for mathematics teaching in the 5th grade]**	Burak	1987	Master's thesis
A Modelagem como Estratégia de Aprendizagem da	Gazzetta	1989	Master's thesis

Matemática em Cursos de Aperfeiçoamento de Professores [Modeling as a mathematics learning strategy in teacher improvement courses]			
O ensino de matemática para adultos através do método modelagem matemática [Mathematics teaching for adults through the mathematical modeling method]	Monteiro	1991	Master’s thesis
Modelagem Matemática: ações e interações no processo de ensino aprendizagem **[Mathematical modeling: actions and interactions in the teaching-learning process]**	Burak	1992	Doctoral thesis
A Modelagem: o Texto e a História Inspirando Estratégias na Educação Matemática **[Modeling: text and history inspiring strategies in mathematics education]**	Corrêa	1992	Master's thesis
A Matemática nas Ciências Aplicadas: uma proposta metodológica **[Mathematics in applied sciences: a methodological proposal]**	Almeida	1993	Master’s thesis
Educação Matemática e Ambiental: um contexto de mudança **[Mathematics and environmental**	Caldeira	1998	Doctoral thesis

education: a changing context]

The theses selected to compose the analytical resource "are investigations produced and evaluated in qualified postgraduate courses in the country and recognized by the Ministry of Education - MEC" (Quartiere, 2012, p. 72). When qualified and recognized by the MEC, those courses legitimate the knowledge produced in universities and recognize that they are taken as true.

After selecting the analytical resources, we focused on them to scrutinize regularities that, in some way, referred to the emergence of the discourse under study. To do so, we sought to analyze, from the utterances that compose the masters' and doctoral theses, how the dispersed intertwines, creates a certain regularity, constitutes statements, and, consequently, makes the discourse of Mathematical Modeling in Mathematics Education emerge, circulate, and function.

The theoretical-methodological tools: the statement

But, what is a statement? From a Foucauldian perspective, there is no room to answer this question since, for such a conception, there is no essence of things; there is no something in itself. Even so, Foucault takes the risk of definitions and describes his understanding of a statement. First, he defines it by opposing what grammarians have called a sentence, logicians have designated a proposition, and analysts have tried to demarcate by *speech act* (Gregolin, 2004). Under this logic, we find utterances where we cannot recognize a sentence: "a family tree, an accounting book, estimates of a commercial balance sheet are statements: where are the sentences?" (Foucault, 2014a, p. 99), i.e., a statement cannot be found through the constituents of the sentence (subject-verb-predicate) (Gregolin, 2004); unlike propositions, there are no equivalent formulations for statements, for example, 'nobody heard' and 'it's true that nobody heard' have the same propositional structure and cannot be considered different. "Now, as statements, these two formulations are neither equivalent nor interchangeable" (Foucault, 2014a, p. 97). The first (nobody listened) can be found in a novel, and the second (it is true, nobody listened) in a dialog fragment.

Although it is the same propositional structure, its enunciative characters are different. We find more utterances than speech acts that we can isolate, so that "it often takes more than one statement to effect a *speech act*: [...] it would be difficult to contest, in each one of them, the *status* of a statement, under the pretext that they are all traversed by one and the same illocutionary act" (Ibidem, p. 100).

Whether or not the statement belongs to the same genre as the sentence, the proposition and the speech act, how can we define it? For Foucault, the statement is not a structure, it is more omnipresent, more tenuous; it is less laden with determinations. Accordingly, we must admit that any series of signs, graphisms, or traits is sufficient to constitute a statement. The statement is "a function that crosses a domain of structures and possible units and makes them appear, with concrete contents, in time and space" (Foucault, 2014a, p. 105).

This enunciative function has its conditions of existence, rules that control it, and a field in which it takes place. To exist, a statement does not have before it a correlate or an absence of correlate, for example, "the mountain of gold is in California" (Foucault, 2014a) does not have a reference that can be found in a geographic map or a travel manual, but can be found in a work of fiction. Its referential is not constituted by "things", "facts", "realities", or "beings" but by laws of possibility. The reference of the statement forms the place, the condition, the field of emergence (Foucault, 2014a, p. 110). The statement is an empty space that can be filled with different subjects who "may come to take a position and thus occupy that place when formulating the statement" (Machado, 2007, p. 151).

Statements do not exist "in isolation, like a sentence or a proposition may do. For them to become statements, they must be an element integrated to a set of statements" (Ibidem, p. 151). Furthermore, another condition for the existence of a statement is its materiality, which is of an institutional nature. "A sentence spoken in everyday life, written in a novel, being part of the text of a constitution, or integrating a liturgy does not constitute the same statement. Its identity depends on its location in an institutional field" (Ibidem, p. 152).

Finally, what determines a statement, or the enunciative function, is "the fact that it is produced by a subject, in an institutional place, determined by socio-historical rules that define and enable it to be stated" (Gregolin, 2004, p. 26).

Once the statement is considered the elementary unit of discourse, what does the utterance consist of? For Foucault (2014a), an utterance is an event that does not repeat itself, which has a situated and dated singularity, which cannot be reduced. We say there is an utterance every time a set of signs is emitted (Foucault, 2014a). The utterance can be restarted and/or recalled while the statement can be repeated. In this work, we are considering an utterance what the authors wrote in their master's and doctoral theses. Each author emits a set of signs that are not repeated, but there is regularity between them. In other words, the set of utterances, of the signs, emitted by the authors, forms a statement. We consider that the utterance is the elementary unit of the statement.

Theoretical-methodological tools: perspectives

Our perspectives were constituted from a set of strategies and some methodological precautions. When scrutinizing the analytical material, we were careful to "[...] analyze the *dictum* as a *monument* and not as a *document*. This means that the reading (or listening) of the statement is done through the exteriority of the text, without actually entering into the internal logic that commands the order of the statements" (Veiga-Neto, 2007, p. 104, emphasis added). That is, we look at the discontinuities in their exteriority, through what surrounds and sustains the statement.

The monumental analysis is not looking for a supposed truth, "it does not even seek an original, remote, founding essence, trying to find, in the unsaid of the discourses under analysis, an ancestral and hidden already-said" (Veiga-Neto, 2007, p. 98). When analyzing discontinuities, we are not looking for something unsaid, because "what we are interested in discovering is already there; it is enough to know how to read" (Ibidem, p. 105).

The analysis was carried out, thus, under an already said. In other words, we analyze what is said, what is written in masters' and doctoral theses, and not the intention they had by saying something or what could be said, which would be hidden in their writing. We analyzed what was said and the conditions that made it possible for that to be said and not something else in its place. That is, we do not seek the unsaid, because "even silences are just silences, for which it is not interesting to look for fillings; they must be read for what they are and not as unsaid that would hide a meaning that did not surface in the discourse" (Ibidem, 2007, p. 98).

From this perspective, the look we cast on the empirical material did not seek to "discover hidden truths, but to make visible exactly what is already visible" (Artières, 2004, p. 15). It is a visible that becomes opaque by its proximity. Giving visibility to the visible is, therefore, shedding light on this opacity and showing what is so close, so connected, indescribably close, that we cannot perceive. Thus, we seek to show what we already see but do not realize we see, precisely because it is "very much on the surface of things" (Foucault, 2013, p. 152).

Our meticulous look also did not seek an origin, it was not in search of the "first time" in which the Modeling was said. The search for an origin is "[...] to strive to collect in it the exact essence of the thing, its purest possibility, its identity carefully collected in itself" (Foucault, 2011, p. 17). The look we cast over the analytical material did not seek an essence for Modeling, nor what this discourse is, nor its origin. In other words, we mapped the provenances, in the form of conditions of possibility for their emergence. This mapping gave visibility to the visible that was opaque in the dispersions of statements concerning the emergence of discourse.

Mathematics is far from reality

> The last two decades have shown that teaching in general and, more particularly, **the teaching of mathematics, is going through one of its most serious crises** with respect to the binomial **teaching-learning**. **The crisis in mathematics teaching has repercussions at all levels of education,** whether 1st, 2nd, or 3rd degrees (Burak, 1987, p. 12, emphasis added).

Careful readings of the empirical material gave visibility to some utterances that signaled a crisis in the teaching of Mathematics from 1970 to 1990. This crisis is evidenced and constituted of statements, which, despite being distinct, are intertwined: (i) students have difficulties in learning Mathematics and (ii) Mathematics is distant from reality.

These statements evidenced and justified the Modeling activities as a possibility to alleviate this crisis. Its use would allow Mathematics teaching to walk in parallel with students' learning and would also serve as a strategy to show the usefulness of this school subject based on activities that relate it to students' reality. In other words, the emergence of Modeling, within the scope of educational concerns, would be related to the possibility of mitigating the difficulty in learning Mathematics and, also, showing its usefulness based on its connection with reality.

In this article, we will problematize one of the conditions of possibility for the emergence of Mathematical Modeling in Mathematics Education based on the statement, "Mathematics is far from reality".

The utterances, extracted from the analytical material, show that the distance between Mathematics and reality occurred at a specific historical moment and made its teaching meaningless. Students saw no sense in learning Mathematics, as it was useless. Below, we outline the utterances:

> What has been observed is that the hasty, premature formalization has not produced good results in Mathematics teaching. **The intention was to induce the student to reach a level of abstraction totally at odds with their maturity; it derived for the** transmission of information and codes, with a demand for the use of symbols and definitions, totally inappropriate, because **disconnected from the student's real experience process**. This alienating process culminated in the use of "Modern Mathematics" (Gazzetta, 1989, p.12, emphasis added).
>
> Students who seek Applied Science courses in general are not motivated towards Mathematics, especially **because they fail to see the apparent relationship between**

> **the content and purpose of their particular area**, because **the traditional teaching methodology usually dissociates Mathematics from each person's life experience and their professional choice**, fragmenting their fundamental education. This work proposes the **Mathematical Modeling as a methodological way to remedy these deficiencies**, bearing in mind that its focus consists precisely in subsidizing real-life problems to introduce the various mathematical techniques specific to the questions (Almeida, 1993, p. 3, emphasis added).
>
> The problem of planting potatoes arose in a Differential and Integral Calculus course for Food Technology students at UNICAMP, taught by Prof. Rodney C. Bassanezi. Despite being the first contact these students would have with Mathematics at the university, many already used the **t-shirt symbol of the course with the saying "I HATE CALCULUS"**. This evidently reflected the feeling of the course's veterans, who saw no satisfactory reason to study three semesters in a row a **"useless" subject**, responsible for the **highest fail rates** of the entire course (Gazzetta, 1989, p. 36-37, emphasis added).
>
> Students often asked: **"What is such content for?" or "Where am I going to use it?"**. The answers, at the time, did not cause serious feelings of guilt. We admit that we did not lie to the students but, on the other hand, we were far from providing them with more dignified answers, consistent with their real question (Corrêa, 1992, p. 8, emphasis added).

The utterances above show that Mathematics teaching intended to *induce the student to reach a level of abstraction that is completely out of line with their maturity,* totally detached *from real student experience***.** The distance is generated because *the traditional teaching methodology usually dissociates Mathematics from the life experience of each subject,* what ended up making Mathematics a *useless subject, responsible for the highest failure rate.* This context also generated complaints from students, *such as "What is this content for?", "Where will I use it?"*, or *"What is the relationship between the content and purpose of its specific area?"* There was no point in learning Mathematics if it had no use outside the school walls.

This destitution of reality in the teaching of Mathematics is intertwined by power/knowledge relations that, at a certain historical moment, insert a technical pedagogy in schools and, along with this pedagogy, "the proposal of teaching Mathematics to be used in extracurricular situations was giving way, during the 1960s, to the teaching of mathematics for the sake of mathematics, mainly due to the Modern Mathematics Movement" (Brito, 2008, p. 16). This Movement proposed modernizing[5] Mathematics teaching and its entry into teaching, according to research, is related to other events –economic, educational, scientific, and

5Such modernization is a continuum of the discourse of other areas of knowledge that sought their modernity: Linguistics, Anthropology, Economics, Literature, Psychology, etc. The 1960s were the peak of structuralism, the search for scientificity, a moment in which "disciplines questioned themselves about their object, the validity of their concepts, and their scientific ambition. [...] The most impressive example is the evolution of mathematics with the Bourbaki group, which will result in the famous modern mathematics" (Dosse, 1993, p. 107). Knowings, mainly those that made up the human sciences, sought their scientificity through structures and, consequently, their modernity.

technological, among others– that were being experienced at this very moment, and that also sought modernization.

The Modern Mathematics Movement (MMM), according to some researches, started in the USA, in the context of the Cold War, with the launching of the *Sputnik*[6] in 1957, by the Soviet Union – USSR (Sousa, 1999; Silva, 2010; Ramos, 2012), as a measure to improve the education of technicians and scientists. This Movement was thought of as a form of reform the Mathematics teaching, adapting it to progress, development, modernization, and technological acceleration (Novaes, Pinto, & França, 2008, p. 3355). In this sense, "modernizing mathematics teaching should prepare qualified human resources to deal with new technologies and the advancement of science" (Arruda, 2011, p. 43).

From a Foucaultian perspective, we could say that there are power relations that put into circulation the discourse on the teaching of Modern Mathematics in schools, aiming to manufcature docile, useful, disciplined bodies (Foucault, 2013b) and able to "work". This Movement aimed to constitute capable subjects for the historical moment in which they lived – progress, technological acceleration, space race, modernization. Identities that are "good" at Math. In other words, it would be the persons' domain of this discourse that would enable the development of a country. Not knowing Mathematics would mean falling behind in the space race.

From this perspective, students should learn Mathematics and master this discourse, become "good at it". This Modern Mathematics was not concerned with "applications", "reality", "usefulness", "or contextualization", it prioritized, based on the Set Theory, the axiomatic thinking, a greater degree of generalization, a high degree of abstraction, greater logical rigor, precision of language (Novaes, Pinto, & França, 2008, p. 3356).

To legitimize the Movement and its insertion in teaching, this Modern Mathematics sought support in the psychological discourse. "The insertion of these new topics and methodologies was based on the studies of the epistemologist Jean Piaget (1896-1980), emphasizing the correspondence between the operational structures of intelligence and mathematical structures" (Arruda, 2011, p. 41).

> **Modern Mathematics**, until then elaborated by mathematicians and not by Mathematics teachers **only began to reflect on teaching when it found support in Psychology**, through the results of research Piaget carried out on children aged 7 and 8 in the 60s. Such results, which, according to the researcher himself, resembled the Bourbakist mother structures and gave importance to the role of sets, referred to studies

6*Sputnik* It was the first artificial satellite put into orbit.

of *genetic analysis of logical-mathematical and concrete operations* (Sousa, 1999, p. 33, emphasis added).

The psychologist Piaget exhaustively showed the **existing correspondence between the algebraic structures and the operative mechanisms of a child's intelligence** (Sangiorgi *apud* Silva, 2007, p. 90, emphasis added).

Piaget believed intelligence develops according to a sequence of steps or stages of mental evolution. These stages are delimited by age and, when moving from one stage to another, the child develops reasoning and coordination skills that make them progress in their way of acting and thinking, enabling them to move to the next stage. [...] there was in the Modern Mathematics Movement an attempt to **link the mathematical proposals advocated by Bourbaki to the theory developed in Piaget's work** and teaching Mathematics based on fundamental structures (Soares, 2001, p. 50-52, emphasis added).

There is, depending on **the intelligence development** as a whole, a spontaneous and gradual construction of elementary logical-mathematical structures, and that these "natural" structures (...) **are much closer to those used by the so-called "modern" mathematics than those used in traditional teaching** (Piaget *apud* Soares, 2001, p. 51, emphasis added).

In the history of MMM, a verified fact was that Bourbaki had **Piaget's contribution**. In his psychogenetic theory he had already established that there were **correspondence between structures of thought with mathematical structures**. To him, the algebraic and topological mother structures and mother structures of order, **characteristic of mathematical thought were the same found in the genesis of human thought** (Novaes, Pinto, & França, 2008, p. 3357, emphasis added).

To justify the importance of Modern Mathematics in teaching, researchers and mathematicians involved in this movement sought support in the true discourse of Psychology, mainly in Piaget's studies[7]. Bringing Psychology to justify the teaching of Modern Mathematics brought scientificity to the Movement.

The relationship between discourses, that is, the search for support through true discourses, was evidenced by Foucault when the philosopher questioned

[...] the way Western literature had to seek support, for centuries, in the natural, in the verisimilar, in sincerity, in science as well - in short, in true discourse [...] the penal system sought its supports or its justification, first, it is true, in a theory of law, then, from the 19th century onwards, in sociological, psychological, medical, psychiatric

7Although it was found that there was a correspondence between the structures of thought and the mathematical structures, "Piaget himself warned about the dangers of an exaggerated interpretation of his theory" (SOARES, 2001, p. 62). "According to Piaget, the great reform in the teaching of mathematics is closer to the subject's spontaneous operations, but the child's actions must be organized with care **not to skip stages of their development**. An observation made by Piaget in relation to school practices of Modern Mathematics was that **Mathematics teachers had an 'abstract spirit by definition' and that they ignored psychological studies**. In the same line of thought, Piaget stated: 'This initial role of logical-mathematical actions and experiences, (...) is the necessary preparation to reach the deductive spirit'. Yet: '**Between 7-11 years [...] the child cannot reason from pure hypotheses expressed verbally and needs, to carry out a coherent deduction, to apply it to manipulative objects'"** (Novaes, Pinto, & França, p.3358, emphasis added).

> knowledge: as if the very word of the law could no longer be authorized, in our society, if not for a true discourse (Foucault, 2014b, p. 18).

In this same logic, the Modern Mathematics Movement sought support in already legitimized discourses, as if Modern Mathematics itself were not authorized in teaching except by a true discourse. Therefore, it is the true discourse of Psychology on the stages of development of intelligence that legitimizes and gives strength to the entry into the teaching of Modern Mathematics, attributing to it [Modern Mathematics] a certain scientificity and, consequently, the recognition of a true discourse.

With Modern Mathematics supported by Psychology, its teaching gains scientific strength being, therefore, legitimized. The "new" Mathematics, having its structures compared to the structures of development, therefore, also emerged as a critique of the so-called traditional curricula (Soares, 2001; Silva, 2007), which would be characterized by mechanical activities that forced "students to memorizing processes instead of understanding them" (Silva, 2007, p. 65). The "exercises had a training character" (Ibidem, p. 65). As a result of this mechanization and memorization, students did not feel motivated to learn Mathematics in the traditional curriculum and the large number of low grades and failures in this discipline highlighted the need for reform (Soares, 2001).

From this Movement, teaching became concerned with excessive abstractions internal to Mathematics itself, "more focused on theory than practice. The language of set theory, for example, was introduced with such emphasis that learning symbols and endless terminology compromised the teaching of calculus, geometry, and measurements" (Brasil, 1997b, p. 20).

> In the case of Brazil, the implementation of the **Modern Mathematics** as part of **the school curriculum could not combat the problems that traditional teaching presented**. It was adopted without the necessary planning and proper teachers' preparation. The teaching of set theory became excessively abstract and exaggerated, and the original proposals of the Movement ended up being lost or never fully accomplished (Soares, 2001, p. 142, emphasis added).

The traditional Mathematics teaching was facing problems, could not cope with the "good-at-Mathematics" identities. Modern Mathematics emerges as a possibility of teaching capable of forming subjects who master not only the mathematical contents, but also the functioning of its structures. The power relationship that is intertwined in the constitution of those "good-at-Mathematics" identities can be confirmed in Begle's speech at the 1st Inter-American Conference on Mathematics Education, held in Bogotá, Colombia, in 1961:

> The need in the United States for **people trained in Mathematics and a general knowledge of Mathematics on the part of all citizens is so great that every possible effort should be made to satisfy** it, (...) The reason for this effort is not to say that we are unhappy with the past, but that **we realize that the future requires greater preparation and mathematical ability from all our citizens** (Begle, 1961 *apud* Soares, 2001, p. 39, emphasis added).

However, this Movement, due to its high degree of abstraction, its deprivation of reality, failed for not "coping with" what it aimed at, *mathematical preparation and ability of all our citizens*. This failure may have generated possibilities for the reconfiguration of teaching and the emergence of new practices.

The mathematics teaching would breathe "renewed air", assuming another position. Thus, abstraction, structure, formalism, and neutrality would compete for space with a *realistic mathematics, real-world mathematics.* The reconfiguration of the mathematics teaching would be generated from the problematization of technical pedagogy and the MMM, which would put into circulation another practice for the teaching of Mathematics and would seek to relate Mathematics with other areas, thus justifying its teaching and its usefulness, as can be seen in the utterances below.

> **We expect a change in the teaching-learning methodology of Mathematics to be fostered**, emphasizing a more personalized study and assessment of the student and the **interdisciplinary applications through concrete and familiar problem situations in the student's daily life** and the community (Sánchez, 1979, p. 76, emphasis added).
> The **real integration between the teaching of Mathematics and other subjects is considered fundamental**, so it is inadequate to substitute real applications for problem solving in the narrow mathematical scope. **Mathematics should be used in "natural situations", in domains outside itself, where a "true" problem is presented**, whose solution requires the intervention of the mathematical method and/or the use of an already developed mathematical theory (Sánchez, 1979, p. 35, emphasis added).
> **The modeling process** offers us one of the ways so that we can **relate mathematics to other branches of knowledge**, making this discipline play an active role within the school context and, ultimately, within the student's life (Müller, 1986, 69, emphasis added)
> The student is expected not only to acquire the mathematical knowledge presented, but also **perceive the relationships of this knowledge with other subjects** to **understand mathematical knowledge better and apply it in other non-mathematical areas.** [...] We seek to work with **Interdisciplinary Mathematical Models** because **life's problems very rarely achieve their solution through a single scientific direction**, which results in that all learning must always consider the **interdisciplinary relationship of human knowledge** (Sánchez, 1979, p. 4, emphasis added).
> When using a **mathematical model as a teaching strategy**, we provide the student **with a more comprehensive view of the mathematics and its relationship to other sciences** because, as we can observe, when starting from a real situation, this one, being within some context, will always have **social, scientific, philosophical, and political aspects to be considered** (Müller, 1986, p. 67, emphasis added).

> The already mentioned objectives for Mathematics teaching-learning lead us to consider the importance of the construction of mathematical models visualizing not only the practical application of the theory but, fundamentally, the expansion of this theory, in the sense of **inferring its application to other fields of human knowledge**, from which the objective 'selection' acquires importance **regarding the contents to be transmitted that allow the disciplinary interrelationship** (Sánchez, 1979, p. 33, emphasis added).
>
> The goals **of Mathematics teaching-learning** must be guided in the sense of "interiorizing" mathematical knowledge in the student, **enabling it for applications** (Sánchez, 1979, p. 31, emphasis added).
>
> By using this strategy of Instructional Modules and Interdisciplinary Mathematical Models combined, **we expect that the student not only acquires the mathematical knowledge presented to hism/her, but also perceives the relationships of this knowledge with other subject** to better understand mathematical knowledge and apply it in other non-essentially mathematical areas. We seek to work with Interdisciplinary Mathematical Models because life's problems very rarely achieve their solution through a single scientific direction. Because of that, **all learning must always consider the interdisciplinary relationship of human knowledge** (Sánchez, 1979, p. 4, emphasis added).
>
> **Models can apply** to occurrences in the most diverse fields, such as **electricity, transport, biology, and economics,** among others. (Wilmer, 1976, p. 53, emphasis added).
>
> The teaching through **modeling** seeks to facilitate the emergence of problem situations as varied as possible**, always within a context, making the studied mathematics more meaningful for the student** (Burak, 1987, p. 17, emphasis added).
>
> The external aspect of mathematics, which involves **the socio-cultural and historical conditions** of the development of mathematical knowledge, **comes to be considered**, together with the content, as one of the bases of new teaching strategies. Furthermore, **the external aspect deals with the relationship of this subject with the others, emphasizing its applicability** (Müller, 1986, p. ii, emphasis added).

The Modeling discourse will be justified because Mathematics would be taught from *a connection of the student's daily life, of the student's interest, concrete problem situations.* Mathematics and its teaching should be carried out with *real problems* of *other branches of knowledge*, i.e., *always considering the interdisciplinary relationship of human knowledge.* This form of teaching, based on "reality", should lead students to *perceive the relationships between this knowledge and other subjects, other sciences.* The content taught must *allow disciplinary interrelationships* and, in this way, students must finish their studies *competent for the applications*.

In effect, when taking a detailed look at the analytical material, we could see that the MMM may have constituted a fertile ground for Modeling to sprout. This was possible because Modeling makes use of another logic, a gear other than abstraction. A new practice comes into play, reconfiguring the teaching of Mathematics based on the student's reality. In this way, there would be a "[...] relationship of forces that is inverted, a confiscated power, a vocabulary retaken and turned against its users, a domination that weakens, stretches, poisons itself and another that makes its entrance masked" (Foucault, 2011, p. 28). Thus, the high degree of abstraction provided by Modern Mathematics weakens and another discourse enters as an event, resuming and reconfiguring the teaching of Mathematics.

Consequently, according to the analyzed materials, teaching Mathematics through Modeling would bring meaning to its learning, as can be seen in the utterances below:

> **Mathematical Modeling proposes a more dynamic, more lively way of teaching mathematics, trying to** make it more **meaningful to students** (Burak, 1987, p. 13, emphasis added).
>
> **Mathematical modeling** as an alternative methodology for mathematics teaching seeks to give the student more freedom to reason, conjecture, estimate, and give vent to creative thinking stimulated by curiosity and motivation. The teaching through modeling seeks to facilitate the appearance of **problem situations as varied as possible, always within a context, making the studied mathematics more meaningful to the student** (Burak, 1987, p. 17-18, emphasis added).
>
> The search for **more meaningful math teaching** has led many mathematics educators to use **Mathematical Modeling** in the teaching-learning process of this science (Monteiro, 1991, p. 110, emphasis added).
>
> We therefore believe that the **Mathematical Modeling** method is one of the possible ways to search **teaching that gives meaning** and pleasure in learning to adult students (Monteiro, 1991, p. 191, emphasis added).
>
> I understand it [referring to Mathematical Modeling] as a method that makes it possible to lead students **to acquire a more meaningful mathematics knowledge through the relationships they establish between the facts of their daily lives and the concepts they seek to provide solutions to the problems raised** (Correa, 1992, p. 24, emphasis added).
>
> Thus, despite a strong improvement in procedures with the use of the text, my attention was still essentially turned to the **Mathematical Modeling** method, through which I tried to demonstrate that it was possible to raise the students' level of interest in such a way as to lead them to a **more meaningful learning** through everyday events (Correa, 1992, p. 31, emphasis added).
>
> They learn mathematics because that "**mathematical content**" was **meaningful** (Caldeira, 1998, p. 64, emphasis added).
>
> Another fundamental aspect is the **survey and formulation of the problem by the student**, thus ensuring a **meaningful learning that represents a** high level of involvement, as the student includes him/herself as a whole in the experience from which he/she learns (Gazzetta, 1989, p.36, emphasis added).
>
> This work method [mathematical modeling] makes Mathematics teaching livelier, more dynamic, and **extremely meaningful to the student** (Burak, 1992, p. 94, emphasis added).
>
> Engaging with mathematical concepts based on the worked examples can make Mathematics teaching more attractive because it **gives meaning to actions developed in the classroom** (Burak, 1992, p. 200, emphasis added).

Modeling would provide a Mathematics teaching from *problem situations* related to *everyday facts* and *significant to the student.* This search for meaning, for a *more dynamic mathematics teaching, has led many mathematics educators to use Mathematical Modeling in* *the teaching-learning process.* Those utterances, indeed, constitute the statement "Mathematical Modeling makes Mathematics teaching and learning more meaningful"[8]. In other words, Mathematical Modeling becomes a space for discussions around reality and mathematics, thus enabling a teaching and learning process "soaked" with meaning.

Conclusion

This article aimed to problematize the conditions of possibility for the discourse of Mathematical Modeling to sprout in Brazilian Mathematics Education. The analysis of the analytical material showed that the emergence of the Modeling discourse occurs amid a crisis in the Mathematics teaching. This crisis stems from two statements: (i) students have difficulty learning Mathematics and (ii) Mathematics is far from reality. In this article, we problematize the statement: "***Mathematics is far from reality***".

The problematization of the statement under study allows us to conclude that the Modeling discourse, through its meaningful teaching, would seek to minimize Mathematics characteristics that were reinforced by the Modern Mathematics Movement: formalism and abstraction. It is important to highlight that, on the one hand, those characteristics lead to a certain empowerment of Mathematics, and, on the other hand, those same characteristics provide it with quite fierce criticism (Autor, 2011). The Modeling discourse will criticize those characteristics and will defend that Mathematics teaching based on Modeling activities would make its learning more *significant to the student,* because their reality would be related to school Mathematics.

In conclusion, the Modern Mathematics Movement prioritized language, symbology, structures, formalism and, consequently, would make the teaching of Mathematics separate from reality. This Movement made it possible for Modeling to be thought of as a way of facing it, as it would provide an interdisciplinary work – minimizing the distance between Mathematics and reality – and, therefore, would bring meaning to the teaching and learning of Mathematics – easing students' difficulties in learning.

Indeed, the Modeling discourse resumes and reconfigures Mathematics teaching, causing abstract practices to be rethought from practices linked to the students' realities.

8 This statement will be problematized in another article.

References

Albuquerque Júnior, D. M. (2008). Michel Foucault e a Mona Lisa ou como escrever a história com um sorriso nos lábios. In: RAGO, Margarete; VEIGA-NETO, Alfredo. (orgs). *Figuras de Foucault.* 2 ed.. Belo Horizonte: Autêntica (pp. 97- 107).

Almeida, G. C. E. (1993). *A Matemática nas Ciências Aplicadas:* uma proposta metodológica. Dissertação (Mestrado em Educação Matemática). Universidade Santa Úrsula. Rio de Janeiro, RJ.

Arruda, J. P. (2011). *Histórias e práticas de um ensino na escola primária*: marcas e movimentos da matemática moderna. 312 f. Tese (Doutorado em Educação Científica e Tecnológica). Programa de Pós-Graduação em em Educação Científica e Tecnológica. Universidade Federal de Santa Catarina, Florianópolis, SC.

Artières, P. (2004). Dizer a Atualidade: O trabalho de diagnóstico em Michel Foucault. In: GROS, Frédéric (org). *Foucault: a coragem da verdade*. São Paulo, Parábola Editorial.

Brasil. (1997b). Secretaria de Educação Fundamental. *Parâmetros Curriculares Nacionais*: matemática. Secretaria de Educação Fundamental. Brasília: MEC/SEF.

Brito, A. de J. (2008). A USAID e o Ensino de Matemática no Rio Grande do Norte. *Bolema*, Rio Claro, SP, ano 21, n. 30. (pp. 1-25).

Burak, D. (1987). *Modelagem Matemática:* uma metodologia alternativa para o ensino de matemática na 5ª série. Dissertação (Mestrado em Educação Matemática). Programa de Pós-Graduação em Educação Matemática. Universidade Estadual Paulista Júlio Mesquita Filho, Rio Claro.

Caldeira, A. D. (1998). *Educação Matemática e Ambiental:* um contexto de mudança. Tese (Doutorado em Educação). Programa de Pós-Graduação em Educação. Universidade de Campinas, Campinas.

Correa, R. de A. (1992). *A Modelagem:* o Texto e a História Inspirando Estratégias na Educação Matemática. Dissertação (Mestrado em Educação Matemática). Programa de Pós-Graduação em Educação Matemática. Universidade Estadual Paulista, Rio Claro.

Dosse, F. (1993). *História do estruturalismo:* o campo do signo, 1945/1966. v. 1. Trad. Álvaro Cabral. São Paulo: Ensaio.

Fonseca, M. S. (2009). Sobre a Matematização do Mundo. *Revista Iberoamericana de Educación*. (pp. 1-9). https://rieoei.org/historico/deloslectores/918Souza.PDF Acesso em: 18 fev. 2016.

Foucault, M. (2011). *Microfísica do poder.* Rio de Janeiro, RJ: Graal.

Foucault, M. (2013). Michel Foucault explica seu último livro. In: ______. *Arqueologia das ciências e história dos sistemas de pensamento.* Ditos e Escritos II. Organização e seleção de textos Manoel Barros da Motta: tradução Elisa Monteiro. 3 ed. Rio de Janeiro: Forense Universitária.

Foucault, M. (2013b). *Vigiar e punir*: história da violência nas prisões. Trad. Raquel Ramalhete. 41ªed. Petrópolis, RJ: Vozes.

Foucault, M. (2014a). *A Arqueologia do Saber*. Trad. Luiz Felipe Baeta Neves. 8ª ed. 3ª tiragem. Rio de Janeiro: Forense Universitária.

Foucault, M. (2014b). *A ordem do discurso:* aula inaugural no Collège de France, pronunciada em 2 de dezembro de 1970. Trad. Laura Fraga de Almeida Sampaio. 24ª ed. São Paulo: Edições Loyola.

Gazzetta, M. (1989). *A Modelagem como Estratégia de Aprendizagem da Matemática em Cursos de Aperfeiçoamento de Professores.* Dissertação (Mestrado em Educação Matemática). Programa de Pós-Graduação em Educação Matemática. Universidade Estadual Paulista, Rio Claro.

Gregolin, M. do R. (2004). O enunciado e o arquivo: Foucault (entre)vistas. In: Sargentini, V.; Navarro-Barbosa, P. (org). *Foucault e os domínios da linguagem:* discurso, poder, subjetividade. São Carlos: Claraluz.

Machado, R. (2007). *Foucault, a ciência e o saber.* 3ª ed. ver. e ampliada. Rio de Janeiro: Jorge Zahar.

Magnus, M. C. M. (2008). *Modelagem Matemática na Educação Matemática Brasileira:* histórias em movimento. 2018. 227 p. Tese (Doutorado em Educação) – Programa de Pós-Graduação em Educação, Universidade Federal de São Carlos, São Carlos.

Müller, M. C. (1986). *Modelos matemáticos no ensino da matemática*. 140 f. Dissertação (Mestrado em Educação). Faculdade de Educação, Universidade Estadual de Campinas, Campinas.

Monteiro, A. (1991). *O ensino de matemática para adultos através do método modelagem matemática.* Dissertação (Mestrado em Educação Matemática). Programa de Pós-Graduação em Educação Matemática. Universidade Estadual Paulista, Rio Claro.

Novaes, B. W. D., Pinto, N. B., França, I. da S. (2008). *Estruturalismo e Matemática Moderna*: dilemas e implicações para o ensino. http://www.pucpr.br/eventos/educere/educere2008/anais/pdf/653_790.pdf Acesso em: 08 mar. 2016.

Quartieri, M. T. (2012). *A Modelagem Matemática na educação básica:* a mobilização do interesso do aluno e o privilegiamento da matemática escolar. 2012. 199f. Tese (Doutorado em Educação). Universidade do Vale do Rio dos Sinos, São Leopoldo.

Ramos, M. M. L. P. (2012). *Modernização da matemática na Bahia*: a experiência com classes-piloto no Colégio Estadual da Bahia – Central (1966-1969). 156 f. Dissertação (Mestrado em Ensino, Filosofia e História das Ciências). Programa de Pós-Graduação em Ensino, Filosofia e História das Ciências. Universidade Federal da Bahia, Salvador.

Sánchez, J. E. P. (1979). *Estratégia combinada de módulos instrucionais e modelos matemáticos interdisciplinares para ensino-aprendizagem de matemática a nível de segundo grau*: um estudo exploratório. 305 f. Dissertação (Mestrado em Educação). Pontifícia Universidade Católica do Rio de Janeiro, Rio de Janeiro.

Silva, D. R. (2010). *Livro Didático de Matemática:* lugar histórico e perspectivas. Dissertação de Mestrado. Faculdade de Educação, Universidade de São Paulo – USP – São Paulo – SP.

Silva, V. (2007). *Osvaldo Sangiorgi e "o fracasso da matemática moderna" no Brasil.* 161 f. Dissertação (Mestrado em Educação Matemática). Pontifícia Universidade Católica, São Paulo.

Soares, F. (2001). *Movimento da Matemática Moderna no Brasil*: avanço ou retrocesso? 203 f. Dissertação (Mestrado em Matemática Aplicada). Programa de Pós-Graduação em Matemática Aplicada. Pontifícia Universidade Católica, Rio de Janeiro, RJ.

Sousa, M. do C. (1999). *A percepção de professores atuantes no ensino de Matemática nas Escolas Estaduais da Delegacia de Ensino de Itu, do Movimento Matemática Moderna e de sua influência no currículo atual*. Dissertação de Mestrado. Faculdade de Educação. Universidade de Campinas – UNICAMP – Campinas – SP.

Veiga-NETO, A. (2007). *Foucault e a Educação.* 2 ed. 1 reimp. Belo Horizonte: Autêntica.

Wilmer, C. B.. *Modelos na aprendizagem da matemática.* 150 f. Dissertação (Mestrado em Ciências da Matemática). Pontifícia Universidade Católica do Rio de Janeiro, Rio de Janeiro.

TRADUTORA E REVISORA: Maria Isabel de Castro Lima