

**THE (RE)INVENTION OF MATHEMATICS TEACHING IN DIGITAL CULTURE:
PERSPECTIVES FOR TEACHER EDUCATION**

**A (RE)INVENÇÃO DO ENSINO DE MATEMÁTICA NA CULTURA DIGITAL:
PERSPECTIVAS PARA A FORMAÇÃO DOCENTE**

**LA (RE)INVENCION DE LA ENSEÑANZA DE LAS MATEMÁTICAS EN LA
CULTURA DIGITAL: PERSPECTIVAS PARA LA FORMACIÓN DOCENTE**

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ABSTRACT

This article, "The (Re)Invention of Mathematics Teaching in Digital Culture: Perspectives for Teacher Education," addresses the crisis of school Mathematics, which still uses traditional and mechanistic methodologies in a world dominated by Digital Culture. It proposes that Digital Culture should be the lens through which pedagogical practice is re-signified, shifting the focus from transmission to the production and application of mathematical knowledge. The new epistemology of mathematical activity values Modeling, Inquiry, and Computational Thinking. The success of this transformation depends unequivocally on Teacher Education, which must be structured around the development of the TPACK model (Technological Pedagogical Content Knowledge) and based on reflective and collaborative practice. The new teaching perspective is hybrid and ubiquitous, manifested in Active Methodologies such as the Flipped Classroom, which optimizes face-to-face time for collaborative problem solving, with the teacher acting as a mediator. In addition, teaching should embrace Mathematical Modeling and the use of real data to develop Data Literacy, essential for the 21st-century citizen. In this redefinition, the teacher becomes a Pedagogical Designer and Knowledge Curator, enabling students to use Mathematics critically, ethically, and as a tool for investigation and digital citizenship.

Keywords: TPACK. Digital Culture. Teacher Education. Mathematical Modeling.

RESUMO

Este artigo, "A (RE)INVENÇÃO DO ENSINO DE MATEMÁTICA NA CULTURA DIGITAL: PERSPECTIVAS PARA A FORMAÇÃO DOCENTE", aborda a crise da Matemática escolar, que ainda utiliza metodologias tradicionais e mecanicistas em um mundo dominado pela Cultura Digital. Propõe que a Cultura Digital deve ser a lente para resignificar a prática pedagógica, deslocando o foco da transmissão para a produção e aplicação de conhecimento matemático. A nova epistemologia do fazer matemático valoriza a Modelagem, a Investigação e o Pensamento Computacional. O sucesso dessa transformação depende inequivocamente da Formação Docente, que deve ser estruturada no desenvolvimento do modelo TPACK (Conhecimento Tecnológico e Pedagógico do

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Conteúdo) e baseada na prática reflexiva e colaborativa. A nova perspectiva de ensino é híbrida e ubíqua , manifestada em Metodologias Ativas como a Sala de Aula Invertida, que otimiza o tempo presencial para a resolução colaborativa de problemas, com o professor atuando como mediador. Além disso, o ensino deve abraçar a Modelagem Matemática, utilizando dados reais para desenvolver a Data Literacy (Alfabetização em Dados) , essencial para o cidadão do século XXI. Nessa redefinição, o professor se torna um Designer Pedagógico e Curador do conhecimento , capacitando o aluno a usar a Matemática de forma crítica, ética e como ferramenta de investigação e cidadania digital.

Palavras-chave: TPACK. Cultura Digital. Formação Docente. Modelagem Matemática.

RESUMEN

Este artículo, "La (Re)Invencción de la Enseñanza de Matemáticas en la Cultura Digital: Perspectivas para la Formación Docente", aborda la crisis de la Matemática escolar, que aún utiliza metodologías tradicionales y mecanicistas en un mundo dominado por la Cultura Digital. Propone que la Cultura Digital sea la lente para resignificar la práctica pedagógica, desplazando el foco de la transmisión hacia la producción y aplicación del conocimiento matemático. La nueva epistemología del hacer matemático valora la Modelización, la Investigación y el Pensamiento Computacional. El éxito de esta transformación depende inequívocamente de la Formación Docente, que debe estructurarse en el desarrollo del modelo TPACK (Conocimiento Tecnológico Pedagógico del Contenido) y basarse en la práctica reflexiva y colaborativa. La nueva perspectiva de enseñanza es híbrida y ubicua, manifestada en Metodologías Activas como el Aula Invertida, que optimiza el tiempo presencial para la resolución colaborativa de problemas, con el profesor actuando como mediador. Además, la enseñanza debe incorporar la Modelización Matemática y el uso de datos reales para desarrollar la Alfabetización en Datos (Data Literacy), esencial para el ciudadano del siglo XXI. En esta redefinición, el profesor se convierte en un Diseñador Pedagógico y Curador del conocimiento, capacitando al estudiante para usar las Matemáticas de manera crítica, ética y como herramienta de investigación y ciudadanía digital.

Palabras clave: TPACK. Cultura Digital. Formación Docente. Modelización Matemática.



1 THE DIGITAL REVOLUTION AND THE SCHOOL MATHEMATICS CRISIS

Mathematics, historically fundamental for scientific and technological development, is today in a crucial dilemma in the school environment. If, on the one hand, the world has become essentially algorithmic, data-driven and permeated by digital devices, on the other hand, the teaching of the discipline still carries the weight of **traditional** and **mechanistic methodologies**, which have little dialogue with the reality of **Digital Culture** (MORAN, 2015a).

The contemporary student is a digital native, exposed to continuous flows of information and very powerful calculation and visualization tools. In this context, the excessive emphasis on the repetition of algorithms and the memorization of formulas, without proper contextualization and investigative exploration, results in disinterest, evasion and, frequently, aversion to Mathematics (KAWASAKI, 2008). The crisis does not lie in the content, but in the **pedagogical perspective**.

Our proposal, in this chapter, is that Digital Culture should not be seen as a mere *addendum* to the curriculum, but rather as the lens through which the entire practice of teaching Mathematics should be **resignified**. The presence of Digital Information and Communication Technologies (DICT) imposes a **new perspective** on the discipline, shifting the focus from transmission to the **production** and **application** of mathematical knowledge in a critical, collaborative and creative way (SCHLEMMER, 2006).

The National Common Curricular Base (BNCC), by introducing **Computational Thinking** and requiring students to use, understand and create digital technologies in a critical way (BRASIL, 2017), reinforces the urgency of this change. However, for this curricular requirement to materialize in the classroom, the focus of our attention needs to be turned, unequivocally, to **Teacher Training**.

2 DIGITAL CULTURE AND THE NEW EPISTEMOLOGY OF MATHEMATICAL DOING

Digital Culture transcends the simple possession of *hardware* or *software*; it refers to a set of social practices, values, and ways of thinking shaped by the ubiquity of technologies (LÉVY, 2010). When integrated into the teaching of Mathematics, this culture modifies the very nature of knowledge and mathematical work in the classroom.



2.1 FROM LABOR TO EXPANDED INTELLECTUAL LABOR

Historically, the mastery of Mathematics has been linked to agility in manual calculation. Today, digital tools (scientific calculators, spreadsheets, *software* such as GeoGebra or Python) take over operational tasks with unattainable precision and speed.

"Technological resources alone will not bring contributions and will be insufficient if used without adapting to the needs of each teacher in line with those of their students" (GAUTÉRIO & RODRIGUES, 2017, p. 89).

This observation moves the teacher from the position of *executor* or *inspector of calculations* to that of **architect of problem-situations**. The new epistemology of mathematical practice values **Modeling, Research and Communication of Results** (BNCC, Specific Competence 5). For example, instead of just calculating the area of a figure, students can use Dynamic Geometry software to **investigate** the relationships between sides, angles and areas, **conjecture** properties and, only then, formalize the concept. This promotes **active, constructive and self-regulating** learning (SCHLEMMER, 2006).

2.2 ALGORITHMIC THINKING AND CODING

Digital Culture emphasizes the importance of **Computational Thinking** as a fundamental skill (BNCC, Specific Competence 2). Programming and algorithmic logic are not exclusive to Computer Science; they are manifestations of logical-mathematical reasoning.

In teaching from this new perspective, Mathematics is now used to **implement algorithms** in simple programming languages. Not only does this make mathematical concepts tangible, but it also empowers the student to:

1. **Decompose** complex problems into smaller logical steps.
2. **Abstract** patterns and create models.
3. **Test** and **debug** solutions, promoting critical thinking.

This approach, by integrating the knowledge of Numbers, Algebra and Geometry with programming, establishes a solid bridge between school Mathematics and the professional practices of the twenty-first century.



3 TEACHER TRAINING FOR CURRICULAR INTEGRATION: THE TECHNOLOGICAL AND PEDAGOGICAL KNOWLEDGE OF CONTENT (TPACK) (PP. 6-9)

If the paradigm shift is indispensable, the **teacher** is the catalyzing agent of this transformation. The training of the Mathematics educator in the digital culture cannot be limited to technical instruction in the use of tools, but must be structured in the development of **Technological and Pedagogical Content Knowledge (TPACK)**, a theoretical model that helps to understand how technology is intertwined with pedagogical and content knowledge (MISHRA & KOEHLER, 2006).

3.1 THE THREE PILLARS OF TPACK IN MATHEMATICS

Table 1

Component	Definition for the Mathematics Teacher
Content Knowledge (CK)	Deep mastery of mathematical concepts (Algebra, Geometry, Statistics, etc.) and their interrelationships.
Pedagogical Knowledge (PK)	Knowledge about the processes of teaching, learning, classroom management and evaluation.
Technological Knowledge (TK)	Ability to use and manage digital technologies and tools (software, applications, platforms).
Pedagogical Content Knowledge (PCK)	Know <i>how</i> to teach specific content (e.g., methods for teaching functions).
Content Technology Knowledge (TCK)	Know <i>which</i> technologies are best suited to represent and exploit content (e.g., GeoGebra for Geometry).
Pedagogical Technological Knowledge (TPK)	Understanding how technology can be used to change teaching and learning methods (e.g., using online <i>quizzes</i> for immediate feedback).
Pedagogical Technological Knowledge of Content (TPACK)	The full ability to integrate technology to transform the teaching of specific content, choosing DICT for pedagogical purposes that enhance the learning of a mathematical concept (e.g., using a simulator to model exponential growth).

Training should ensure that the future teacher not only knows DICT, but knows how to **integrate them to transform** practices (CIRIÁCO; AZEVEDO; CREMONEZE, 2021). The challenge, as pointed out by some studies, is that many teachers still find **it difficult**



to adapt **Mathematics content to technologies**, seeking specific training to overcome this gap.

3.2 TRAINING BASED ON COLLABORATIVE PRACTICE

TPACK development is most effective when training is based on **reflective practice** and **collaboration**. Online or face-to-face **Communities of Practice (CoP)**, where teachers (in initial or continuing education) meet to plan, execute, and evaluate didactic sequences mediated by DICT, emerge as powerful spaces for professional development (SANTOS, 2021). In these communities, the exchange of experiences and the resolution of problems together promote an enriched environment, expanding the experience of future teachers

4 TEACHING MATHEMATICS FROM A NEW PERSPECTIVE: THE HYBRID AND THE UBIQUITOUS

The new perspective of teaching Mathematics is **hybrid** and **ubiquitous**.

4.1 BLENDED LEARNING AND THE TRANSFORMED DYNAMICS OF THE CLASSROOM

Today's teaching and learning are increasingly **blended** or **hybrid**, mixing the physical space of the classroom with the multiple digital spaces of everyday life (MORAN, 2015a). This programmatic integration is not random, but rather a pedagogical strategy that aims to maximize engagement and the depth of learning, breaking with traditionalism. This implies the use of **Active Methodologies**, such as the **Flipped Classroom** or the Rotation by Stations, **where the student assumes a central role in the construction of their own knowledge**.

In Mathematics, the operational translation of *Blended Learning* is clearly manifested in the intentional separation of moments of contact with the content:

- **Online Moment (At Home – Initial Exploration):** The student accesses **video classes** curated by the teacher, **interactive tutorials** or **simulators** (such as those of Phet Interactive Simulations) to have the first contact with the new concept (e.g., the graphical and parametric analysis of **quadratic** functions). This phase allows each student to advance at their own pace, revisiting the material as many times as necessary. This step **frees up** the in-person time of passive exposure.

- **Face-to-face Moment (At School – Application and Problem Solving):** The teacher uses the time in the classroom, now valuable, not for frontal transmission, but for the **collaborative resolution of complex problems**, the **debate** of mathematical models and the **mediated interaction** with *software* that allows **in-depth experimentation** and **dynamic** visualization (GeoGebra, for example). This is where the teacher acts as a **mediator**, facilitating *insights* and correcting conceptual misconceptions in real time, dedicating focused attention to those with the greatest difficulties. The physical environment becomes a laboratory for construction and argumentation (SCHLEMMER, 2006).

This approach not only optimizes class time, but also caters to the **different learning styles and rhythms of** students, fostering **autonomy** and **responsibility** over the process itself. The flexibility of blended learning is therefore a key element for the **personalization** of Mathematics teaching, making it more inclusive and effective. Mathematics is no longer a set of rules to be followed and becomes a **research tool** (MORAN, 2015b).

4.2 MATHEMATICAL MODELING AND *DATA LITERACY*: THE MATHEMATICS OF THE DATA SOCIETY

Digital Culture has transformed society into a **data society**. The ability to collect, process, and interpret massive volumes of information is the engine of contemporary economics and science. Consequently, the new perspective of teaching Mathematics must embrace **Mathematical Modeling** as a central axis, using the **real data** (socioeconomic, environmental, health, etc.) available in abundance on the internet. This practice gives **immediate meaning** to the concepts studied, linking the abstract to the concrete.

By working with **electronic spreadsheets** (Excel, Google Sheets) and statistical **software**, students not only calculate results, but are compelled to **critically analyze reality**, interpret rates, growth rates (exponential, logistic) and produce **arguments based on quantitative evidence**, as required by the BNCC (EM13MAT104). For example, analyzing population growth or the unemployment rate using public data turns the role or progression class into a **basic data science exercise**.

In this process, **Data Literacy** is developed, which is the essential ability to read, analyze, argue and communicate with data, critically and ethically. This includes understanding how data is collected, how it can be biased, and how graphical representations can distort reality. This skill, which mixes statistics, probability and logical-

mathematical reasoning, is **indispensable for the citizen of the twenty-first century**, ensuring that he not only passively consumes information, but questions it and actively uses it to intervene in his world. Modeling and *Data Literacy* are the fertile field where **Computational Thinking** meets the **social application** of Mathematics.

5 FINAL CONSIDERATIONS: THE MATHEMATICS TEACHER AS CURATOR AND PEDAGOGICAL DESIGNER IN DIGITAL CITIZENSHIP

The **(Re)inventing of the teaching of Mathematics in Digital Culture** is a continuous and challenging process, a true pedagogical infrastructure project that requires courage, investment and constant training on the part of teachers. It is not just about updating tools, but about redefining the didactic contract established in the teacher-student-knowledge relationship (BASILAIA & KVAVADZE, 2020).

In summary, the journey outlined in this chapter allows us to conclude that:

- Digital Culture imposes the **definitive overcoming** of the teaching model centered on transmission and memorization. Mathematical knowledge, now easily accessible, requires the school to focus on **know-how** and **know-how**.
- The new perspective prioritizes **investigation, modeling, algorithmic reasoning and collaboration**, all enhanced and intermediated by Digital Information and Communication Technologies (DICT).
- **Teacher Training**, based on the **TPACK** model (MISCARA & KOEHLER, 2006), emerges as the determining factor for the success of integration. The teacher urgently needs to be trained to be a **Pedagogical Designer** of hybrid and rich learning experiences.

The Teacher as Designer and Curator

The concept of **Pedagogical Designer** implies that the teacher is not only a consumer of didactic material, but the **architect** of the learning paths. It selects, adapts, and combines digital and non-digital resources to create environments that encourage mathematical exploration. This role is complemented by the role of **Curator** of knowledge in the age of informational overload. It is up to the teacher to filter the vast universe of data and resources available, choosing those that are pedagogically valid, conceptually rigorous, and aligned with learning objectives (NASCIMENTO et al., 2024).



Ethics, Criticism and Digital Citizenship

However, the new perspective of Digital Mathematics goes beyond the development of technical skills. It touches on the sphere of **ethics** and **citizenship**. Teaching Mathematics in Digital Culture is also enabling the student to:

1. **Question** the origin and manipulation of data (Modeling and *Data Literacy*).
2. **Understand** the inner workings of the algorithms that govern their lives, demystifying the technological "black box".
3. **Evaluate** the social and political impact of technologies, using mathematical reasoning to analyze inequalities and propose solutions.

It is at this point that teacher training reaches its highest level: by integrating technology in a **critical, meaningful, reflective and ethical** way, as recommended by General Competence 5 of the BNCC (BRASIL, 2017).

Despite the challenges related to infrastructure (which can make classes in digital molds unfeasible, according to some reports, Source 2.1) and inertial resistance to changing practices (NUNES & GROSSI, 2022), the possibilities of building a more **alive, critical, and deeply relevant Mathematics** are vast. Collaboration **networks** and **emancipatory and practical training** are, therefore, the most promising ways for the Mathematics teacher to become, in fact, the curator and mediator of knowledge in the algorithmic era.

Only a well-prepared teacher, who integrates technology, pedagogy and content, ensuring the full development of **TPACK**, will make Mathematics a discipline that not only prepares for the job market, but that, above all, actively contributes to the **formation of digital citizenship** and to the construction of a fairer and more conscious society.

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