

**DECADES OF INCONSISTENCIES IN EXCEL AND MICROSOFT'S STRATEGIC SILENCE: IMPLICATIONS FOR MATHEMATICAL ACCURACY AND GLOBAL EDUCATION**

**DÉCADAS DE INCONSISTÊNCIAS NO EXCEL E O SILENCIO ESTRATÉGICO DA MICROSOFT: IMPLICAÇÕES PARA A PRECISÃO MATEMÁTICA E A EDUCAÇÃO GLOBAL**

**DÉCADAS DE INCONSISTENCIAS EN EXCEL Y EL SILENCIO ESTRATÉGICO DE MICROSOFT: IMPLICACIONES PARA LA PRECISIÓN MATEMÁTICA Y LA EDUCACIÓN GLOBAL**



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**ABSTRACT**

The Microsoft Excel software is widely used as an educational tool in schools, universities, and professional environments. However, it presents conceptual, operational, and semantic limitations that compromise both pedagogical rigor and mathematical reliability. This article analyzes recurrent failures in calculations, nomenclature, Boolean logic, and operator precedence, highlighting their significant impact on the teaching of mathematics, statistics, and finance. Comparative tests were carried out among Excel, Windows Calculator, Copilot, and free spreadsheet software, revealing conceptual discrepancies and inconsistent results. Although the Windows Calculator shares some divergences, it performs correctly the calculations that Excel evaluates inaccurately, suggesting that the origin of such inconsistencies lies in structural decisions within the software. It was also observed that Excel Copilot can overcome part of these errors, indicating that the corrections are technically feasible, although not yet incorporated into the traditional version. The article proposes that Microsoft implement parallel functions — semantically precise and pedagogically appropriate — capable of coexisting with the current ones, reconciling historical compatibility with greater conceptual accuracy. In addition to operational limitations, semantic inconsistencies were identified in mathematical functions and in the VBA language, which may contribute to the development of imprecise concepts. Teaching with Excel is different from calculating with Excel — and this discrepancy may compromise the education of millions of students worldwide.

**Keywords:** Microsoft Excel. Mathematical Errors. Semantic Inconsistencies. Boolean Logic. Operator Precedence. VBA. Pedagogical Impact. Spreadsheets.

**RESUMO**

O Microsoft Excel é amplamente utilizado como ferramenta educacional em escolas, universidades e ambientes profissionais. No entanto, apresenta limitações conceituais, operacionais e semânticas que comprometem o rigor pedagógico e a confiabilidade

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matemática. Este artigo analisa falhas recorrentes em cálculos, nomenclatura, lógica booleana e precedência de operadores, evidenciando impactos significativos no ensino de matemática, estatística e finanças. Foram realizados testes comparativos entre o Excel, a Calculadora do Windows, o Copilot e planilhas gratuitas, revelando discrepâncias conceituais e resultados inconsistentes. A Calculadora do Windows, embora compartilhe algumas divergências, executa corretamente cálculos que o Excel avalia de forma equivocada, sugerindo que a origem das inconsistências está em decisões estruturais do software. Observou-se ainda que o Copilot é capaz de contornar parte dessas falhas, indicando que as correções são tecnicamente viáveis, embora ainda não incorporadas à versão tradicional. Propõe-se que a Microsoft implemente funções paralelas — semanticamente precisas e pedagogicamente adequadas — que possam coexistir com as atuais, conciliando compatibilidade histórica com maior precisão conceitual. Além das limitações operacionais, identificam-se inconsistências semânticas em funções matemáticas e na linguagem VBA, as quais podem contribuir para a formação de conceitos imprecisos. Ensinar com Excel é diferente de calcular com Excel — e essa discrepância pode comprometer a formação de milhões de estudantes em todo o mundo.

**Palavras-chave:** Microsoft Excel. Erros Matemáticos. Inconsistências Semânticas. Lógica Booleana. Precedência de Operadores. VBA. Impacto Pedagógico. Planilhas Eletrônicas.

## RESUMEN

Microsoft Excel es ampliamente utilizado como herramienta educativa en escuelas, universidades y entornos profesionales. Sin embargo, presenta limitaciones conceptuales, operativas y semánticas que comprometen el rigor pedagógico y la confiabilidad matemática. Este artículo analiza fallas recurrentes en cálculos, nomenclatura, lógica booleana y precedencia de operadores, evidenciando impactos significativos en la enseñanza de las matemáticas, la estadística y las finanzas. Se realizaron pruebas comparativas entre Excel, la Calculadora de Windows, Copilot y hojas de cálculo gratuitas, revelando discrepancias conceptuales y resultados inconsistentes. La Calculadora de Windows, aunque comparte algunas divergencias, ejecuta correctamente cálculos que Excel evalúa de manera errónea, lo que sugiere que el origen de las inconsistencias reside en decisiones estructurales del software. También se observó que Copilot es capaz de sortear parte de estas fallas, lo que indica que las correcciones son técnicamente viables, aunque aún no se han incorporado a la versión tradicional. Se propone que Microsoft implemente funciones paralelas — semanticamente precisas y pedagógicamente adecuadas— que puedan coexistir con las actuales, conciliando la compatibilidad histórica con una mayor precisión conceptual. Además de las limitaciones operativas, se identifican inconsistencias semánticas en funciones matemáticas y en el lenguaje VBA, las cuales pueden contribuir a la formación de conceptos imprecisos. Enseñar con Excel es diferente de calcular con Excel, y esta discrepancia puede comprometer la formación de millones de estudiantes en todo el mundo.

**Palabras clave:** Microsoft Excel. Errores Matemáticos. Inconsistencias Semánticas. Lógica Booleana. Precedencia de Operadores. VBA. Impacto Pedagógico. Hojas de Cálculo.

## 1 INTRODUCTION

The use of electronic spreadsheets as a didactic resource has intensified in recent decades, especially with the popularization of Microsoft Excel in school, university and professional environments. Borges (2022) highlights that the use of technological resources, such as worksheets, contributes to teachers making their classes more dynamic and more attractive to students.

Its accessible interface and widespread institutional adoption have made Excel a nearly ubiquitous tool in mathematics, statistics, and finance education. However, this ubiquity hides technical and conceptual limitations rarely discussed in depth — which can compromise the conceptual training of students.

Technical analysis indicates that Excel has inconsistencies in calculations, nomenclature, Boolean logic, precedence of operators, and decimal precision. Such divergences not only affect the reliability of the results, but also perpetuate conceptual misconceptions, especially when associated with functions whose names contradict academic terminology. The situation is aggravated when it is observed that these limitations also extend to the Visual Basic for Applications (VBA) language, used for automations and programmable logic within the tool itself.

This article proposes a critical analysis of these problems, highlighting that, although technically solvable, these flaws have not yet been corrected by Microsoft.

For analysis, comparative tests were carried out between Excel, VBA, Copilot, Windows Calculator and free spreadsheets (Google Sheets and LibreOffice Calc).

The absence of updates suggests a prioritization of historical compatibility over conceptual precision—setting up a silent technical debt that affects millions of spreadsheets already saved.

It should be noted that the observations and comparisons presented in this study are strictly technical and academic in nature, with the objective of contributing to the improvement of digital tools used in the teaching of quantitative disciplines. At no time does this work intend to disparage trademarks, nor to suggest misconduct on the part of their developers.

The analyses developed here seek to promote constructive reflections on the operational and conceptual limitations that impact educational training, reinforcing the need for solutions that reconcile historical compatibility and mathematical precision.

## 2 THEORETICAL FOUNDATION

### 2.1 MATHEMATICAL FOUNDATIONS AND EXCEL INCONSISTENCY

Microsoft Excel is widely used in the teaching of mathematics, statistics, and finance, and is often recognized as a benchmark for computational accuracy. In research on its educational use, Macêdo (2016) states that this tool allows the student to view the results of calculations and functions in a dynamic way, which facilitates understanding and stimulates logical reasoning.

According to the National Curriculum Parameters for High School (BRASIL, 1997, p. 46), "the student must properly use technological resources as instruments of production and communication, recognizing their limitations and potentialities". In this sense, Excel can be used to introduce and develop content, preparing the student to deepen concepts already worked on.

Perius (2012) observes that the teaching and learning process, combined with experimentation and the construction of knowledge, favors the autonomy of the student and expands the environment of possibilities in the teaching of Mathematics, especially with the use of digital technologies. Bianchini (2015) adds that this type of computational resource shifts the focus from calculation to interpretation and the interrelationships between the phenomena studied, reducing the time allocated to operations and graphs.

However, this confidence conflicts with persistent conceptual errors that compromise mathematical logic and the educational process. An emblematic example is the expression  $-2^2$ , which, according to the precedence of operators defined by formal mathematics, should result in  $-4$ . Excel, however, interprets it as  $(-2)^2$ , returning **+4**. This error was documented by Gonçalves (2014, p. 90) and remains uncorrected to this day.

These failures, ignored for more than a decade, accumulate a silent technical debt that affects spreadsheets already used in educational and professional environments. While Microsoft has made important advances in several areas of Excel—such as SEERRO, SOMASE, and XLOOKUP—it has yet to demonstrate the same commitment to improving its basic mathematical expressions. In view of this, it is questioned why such inconsistencies remain in the commercial version of Excel, considering the impacts they can generate in global education.

This evidence reinforces what this study calls Microsoft's 'strategic silence' — the persistence of known inconsistencies, maintained for reasons of historical compatibility, but which compromise the conceptual precision and pedagogical potential of Excel.

### Note 1: Incorrect Evaluation of Chained Exponentiation

The expression  $2^3^2$  reveals a conceptual inconsistency in the way traditional Excel and Windows Calculator interpret exponentiation precedence. Mathematically, the operation is right-associative:  $2^3^2 = 2^9 = 512$ . However, both tools evaluate from left to right, such as  $(2^3)^2 = 64$ . This error, documented by Gonçalves (2025, p. 20553), remains uncorrected. In contrast, Excel's Copilot and Google Sheets correctly return 512, demonstrating that mathematical logic can be preserved through technical review. This divergence compromises the teaching of potentiation and the reliability of calculations in educational and professional contexts.

#### Comparison of the expression $2^3^2$ in different environments

##### Traditional Excel

**Result:** 64

**Rating:** Interprets  $2^3^2$  from left to right, as  $(2^3)^2$ .

**Technical comment:** Contradicts the formal mathematical convention, which requires right-to-left evaluation.

**Pedagogical impact:** It can induce conceptual error in students when teaching chained potentiation.

**Figure 1**

EXCEL			MATHEMATICS	
1	2	3	2	3
FORMULA	FORMULATEXT	POWER	POWER	
64	$=2^3^2$	64		512

Source: The author, 2025.

##### Visual Basic for Applications (VBA)

**Result:** 64

**Rating:** Interprets  $2^3^2$  from left to right, as  $(2^3)^2$ .

**Technical Comment:** The flaw lies in the language precedence logic, not just the Excel interface.

**Pedagogical impact:** Affects educational algorithms and reinforces the technical debt present in native Excel programming.

**Figure 2**

C3	A	B	C	D	E	F	G
<b>EXCEL   VBA</b>						<b>MATHEMATICS</b>	
<b>FORMULA</b>		<b>FORMULATEXT</b>			<b>POWER</b>		
3	64	=2^3^2	64				512

```

Function TEST1(BASE As Double, EXPONENT1 As Double, EXPONENT2 As Double)
    TEST1 = BASE ^ EXPONENT1 ^ EXPONENT2
End Function

```

Source: The author, 2025.

### Windows Calculator

**Result:** 64.

**Rating:** Also interprets  $2^3^2$  from left to right.

**Technical comment:** It reproduces the same behavior observed in Excel, evidencing a structural inconsistency between tools in the same ecosystem.

**Pedagogical impact:** It can compromise trust in basic resources used in the classroom.

**Figure 3**



Source: The author, 2025.

### Excel Copilot

**Result:** 512

**Rating:** Correctly interprets  $2^3^2$  as  $2^{(3^2)}$ .

**Technical Comment:** Demonstrates that the fix is technically feasible within the Microsoft ecosystem itself.

**Pedagogical impact:** Reinforces the importance of technical revisions to preserve mathematical logic.

**Figure 4**

**Copilot** ① 2<sup>3<sup>2</sup></sup>

To evaluate the expression  $2^{3^2}$ , you need to follow the order of operations, specifically the rule for exponents:

1. First, calculate the exponent in the superscript:  
 $3^2 = 9$
2. Then raise 2 to that power:  
 $2^9 = 512$

**Final answer:** 512

Source: The author, 2025.

### Google Sheets

**Result:** 512

**Rating:** Correctly interprets  $2^{3^2}$  as  $2^{(3^2)}$ .

**Technical comment:** Respects formal mathematical convention and evidences adherence to the correct order of precedence.

**Pedagogical impact:** Offers a reliable and conceptually accurate alternative to teaching empowerment.

**Figure 5**

C3	A	B	C	E
1	<b>EXCEL</b>		<b>MATHEMATICS</b>	
2	FORMULA	FORMULATEXT	POWER	POWER
3	512	=2 <sup>3<sup>2</sup></sup>	512	512

Source: The author, 2025.

## 2.2 OPERATOR PRECEDENCE AND LOGICAL AMBIGUITIES IN EXCEL

### Observation 1: The Evidence of Conflict – The Silent Impact of Excel on Global Education

The inconsistency in the evaluation of the expression  $-2^2$  by Excel — which returns **+4** when applying potentiation before negation — was documented by Gonçalves and Rodrigues (2013, p. 3511) in the work *Electronic Spreadsheet: Building Knowledge for Social Practices*. The same error occurs in the VBA language, and the authors suggest the use of

explicit parentheses to ensure correct precedence, reinforcing the need for technical improvements in the teaching of mathematics and computing.

### Traditional Excel

**Description:** Excel returns **+4** when interpreting  $-2^2$  as  $(-2)^2$ , contrary to the mathematical rule that applies potentiation before negation.

**Impact:** Compromises operator precedence teaching.

**Figure 6**

EXCEL				MATHEMATICS	
SIGN & BASE		EXPONENT	POWER	FORMULATEXT	
1	-2	2	4	$=A3^B3$	
2				POWER	
3				-4	

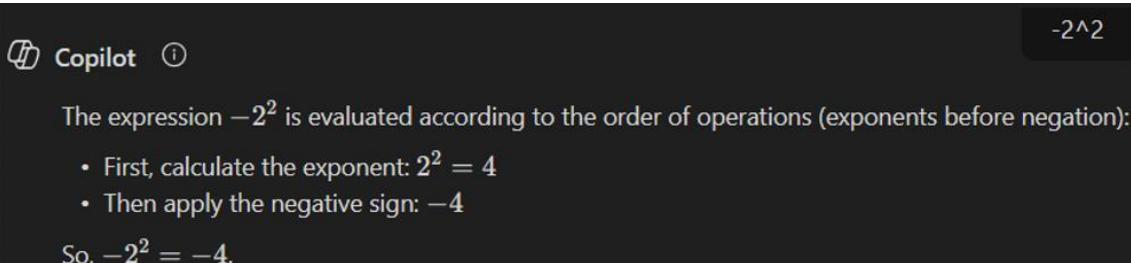
Source: The author, 2025.

### Copilot do Excel

**Description:** Copilot correctly interprets the expression  $-2^2$ , applying the potentiation before the negation, and returns **-4**, according to the formal mathematical rule.

**Impact:** Reinforces the correct logic of operator precedence, contributing to accurate math teaching.

**Figure 7**

 Copilot ①

The expression  $-2^2$  is evaluated according to the order of operations (exponents before negation):

- First, calculate the exponent:  $2^2 = 4$
- Then apply the negative sign:  $-4$

So,  $-2^2 = -4$ .

Source: The author, 2025.

### Windows Calculator

**Description:** The Windows Calculator also correctly interprets the expression  $-2^2$ , returning **-4**, in accordance with mathematical precedence.

**Impact:** Provides a reliable alternative to simple calculations, aligned with formal mathematical fundamentals.

**Figure 8**



Source: The author, 2025.

### Visual Basic for Applications (VBA)

**Description:** VBA evaluates the expression  $-2^2$  as  $(-2)^2$ , returning **+4**, which contradicts the formal mathematical convention, which establishes the application of potentiation before negation.

**Impact:** May compromise the accuracy of automated calculations and didactic clarity in educational settings.

**Figure 9**

EXCEL				MATHEMATICS	
SIGN & BASE	EXPONENT	POWER	FORMULATEXT	POWER	
-2	2	4	=TEST1(A3;B3)		-4
Function TEST1(BASE As Double, EXPONENT As Double) As Double					
TEST1 = BASE ^ EXPONENT					
End Function					

Source: The author, 2025.

### Note 2: Incorrect Boolean evaluation: $(-2)^2 = -2^2$ , true for Excel, false for Math Traditional Excel

**Description:** Microsoft Excel evaluates the expression  $-2^2 = (-2)^2$  to TRUE, ignoring mathematical precedence between operators. This behavior occurs because Excel interprets  $-2^2$  as  $(-2)^2$ , assigning the value 4 to both expressions and therefore considering them equivalent in a Boolean comparison.

**Impact:** This misevaluation compromises the reliability of mathematical, educational, and financial models built in Excel. By reproducing a mistaken algebraic logic, software negatively influences the conceptual formation of millions of users, especially in academic and technical contexts.

**Figure 10**

		C3	▼	✖ ✓ fx ▾	=-2^2=(-2)^2	
1	A	B	C	D	E	
<b>EXCEL</b>						<b>MATHEMATICS</b>
2	FORMULA	FORMULATEXT	RESULT		RESULT	
3	TRUE	=-2^2=(-2)^2	TRUE		TRUE	FALSE

Source: The author, 2025.

The Boolean inconsistency observed in Microsoft Excel—in which the expression  $-2^2 = (-2)^2$  returns TRUE—is evidence of a significant conceptual flaw. Although the principles of formal mathematics state that  $-4 \neq 4$ , Excel applies internal logic that ignores the precedence of operators, treating both expressions as equivalent.

### Copilot

**Description:** When asked about the difference between  $-2^2$  and  $(-2)^2$ , Copilot correctly interprets the mathematical precedence and answers: "Therefore,  $-2^2 = -4$  and  $(-2)^2 = 4$ ", demonstrating that it understands the algebraic distinction between the two expressions, even though Excel does not process them correctly in a Boolean comparison.

**Impact:** Copilot's correct answer reinforces its role as a reliable tool for conceptual validation and support for mathematical reasoning, guiding the user to avoid misinterpretations and adopt more precise procedures, even without directly interfering with the Excel logic.

**Figure 11**

Is  $-2^2$  different from  $(-2)^2$ ?

 Copilot ⓘ

Yes, they are different because of operator precedence:

- $-2^2$  means the negative sign applies **after** the exponent. So:

$$-2^2 = -(2^2) = -4$$

- $(-2)^2$  means the negative number is squared. So:

$$(-2)^2 = (-2) \times (-2) = 4$$

**Key rule:** Exponentiation has higher precedence than unary negation in standard math notation.

Source: The author, 2025.

### Note 3: Propagated Error in Excel: The Inconsistency Affecting the IF Function Logic

Excel's behavior goes beyond an isolated calculation — it compromises the logic of the IF function, one of the most fundamental in the platform. When evaluating the expression  $-2^2 = (-2)^2$ , Excel returns "True", revealing an interpretation that is incompatible with formal mathematical convention. The formula `=IF(-2^2 = (-2)^2; " True"; " False")` illustrates this behavior, where the result is displayed as text, rather than as the default logical value TRUE.

In contrast, Excel's Copilot correctly interprets operator precedence, resulting in:

$$-2^2 \rightarrow -(2^2) \rightarrow -4$$

$$(-2)^2 \rightarrow 4$$

$$-4 = 4 \rightarrow \text{FALSE}.$$

This shows that while Copilot's logic engine respects mathematical convention, traditional Excel still propagates errors that compromise logical decisions and the teaching of arithmetic. The persistence of this failure affects the reliability of the tool and can have significant impacts — including financial ones — on global mathematics education.

**Figure 12**

		C3			
			$\times \checkmark f_x \checkmark$	=IF(-2^2=(-2)^2; "True"; "False")	
		A	B	C	E
EXCEL					
1					
2		FORMULA	FORMULATEXT	RESULT	RESULT
3		True	=IF(-2^2=(-2)^2; "True"; "False")	True	False

Source: The author, 2025.

**Figure 13**

Explain the result of the formula =IF(-2^2=(-2)^2,"True","False")

 Copilot ⓘ

Great question! This formula demonstrates how operator precedence and parentheses affect calculations in Excel.

**Formula:**  
 $=IF(-2^2=(-2)^2,"True","False")$

**Step-by-Step Evaluation:**

- Understand operator precedence in Excel:**
  - Exponentiation (^) happens **before** negation (-).
  - So  $-2^2$  is interpreted as  $-(2^2)$ .
- Evaluate each side of the comparison:**
  - Left side:**  $-2^2$ 
    - First calculate  $2^2 = 4$
    - Then apply the negative sign:  $-(4) = -4$ .
  - Right side:**  $(-2)^2$ 
    - Parentheses force -2 to be squared:  $(-2)^2 = 4$ .
- Comparison:**  
 $-4 = 4?$  → **False**.
- IF function result:**  
Since the comparison is false, the formula returns "False".

 **Final Answer:** The formula returns "False" because  $-2^2$  equals -4, while  $(-2)^2$  equals 4.

Source: The author, 2025.

#### **Note 4: The Excel Paradox: How a New Function Reveals a Decades-Old Error**

Analysis of the Power\_Test function (defined by the expression =LAMBDA(x; y; x^y)) reveals that Excel's problem is not just a miscalculation, but a persistent logical contradiction. The function, introduced in 2021, reproduces the same inconsistency that has persisted for decades in the program's standard notation. As pointed out by Gonçalves (2014, p. 20), this recurrence suggests that the origin of the problem is rooted in structural decisions related to the precedence of operators, and not in recent implementation limitations.

When executed with the variables A9 = -2 and B9 = 2, the function returns **+4**, corresponding to the evaluation of  $(-2)^2$ . However, Excel's standard notation  $(-2^2)$  also produces **+4**, contrary to the formal mathematical convention that the correct result would be **-4**.

This inconsistency demonstrates that while Microsoft has incorporated modern and efficient functions, an engineering decision made decades ago remains unchanged. This raises questions about software development priorities and the responsibility for algebraic accuracy in globally used tools. The observed behavior is therefore the result of a design decision — and not a technical limitation.

Figure 14

C9		A	B	E F	
1					
2					
3					
4					
5					
6					
7					
8	Sign & Base	EXONENT	POWER (LAMBDA)	FORMULATEXT	MATHEMATICS
9	-2	2	4	=Power_Test(A9;B9)	POWER -4

The screenshot shows a Microsoft Excel spreadsheet with a formula editor dialog box open. The formula in cell C9 is =Power\_Test(A9;B9). The formula editor shows the name 'Power\_Test' is defined in the 'Workbook' scope and refers to the formula =LAMBDA(x;y; x ^y). The 'OK' button is highlighted. The table below shows the results of the formula in different contexts: Sign & Base, EXONENT, POWER (LAMBDA), and FORMULATEXT, all resulting in 4, while MATHEMATICS shows -4.

Source: The author, 2025.

### 2.3 LIMITATION OF ROOT CALCULATIONS AND INCONSISTENCY BETWEEN MICROSOFT TOOLS

The limitation of Excel's calculation mechanism becomes evident when analyzing the expression  $= -4^{(1/2)}$ . According to mathematical convention, the precedence of operators determines that, in this expression, the potentiation must be processed before the application of the negative sign, resulting in -2. However, traditional Excel has a constraint in its architecture when performing this operation, returning the error #NÚM!, which indicates an inability to process the square root of a positive number preceded by a negative sign.

The impact of this failure is clearly noticeable when comparing Excel's result with that of other Microsoft tools. Excel Copilot and Windows Calculator interpret the expression correctly, returning the value -2. This discrepancy demonstrates that the problem does not stem from technical constraints, but from the permanence of a calculation engine based on old design decisions. Such inconsistency imposes an unnecessary obstacle to the teaching of algebra and reinforces the argument that traditional Excel does not ensure the elementary conceptual precision expected of a tool with a global reach.

Table 1

Resource	Result	Technical Comment	Impact on the Thesis
		Failure to process precedence	Evidence of failure in the calculation engine and

Traditional Excel	#NÚM!	negation and fractional power, resulting in a miscalculation.	inconsistency with the rest of the Microsoft ecosystem.
Copilot do Excel	-2	It correctly interprets precedence (Potency before Negation), aligning itself with the universal mathematical rule.	It demonstrates that the fix is technically feasible and implemented on the latest Microsoft technology.
Windows Calculator	-2	It follows the pattern of formal mathematical precedence.	Offers a reliable alternative in line with mathematical rigor

Source: The author, 2025.

### Traditional Excel Result for $=-4^{1/2}$

**Figure 15**

EXCEL		MATHEMATICS	
FORMULA	FORMULATEXT	ROOT	ROOT
#NUM!	$=-4^{1/2}$	#NUM!	-2

Source: The author, 2025.

### Excel Copilot Result for $=-4^{1/2}$

**Figure 16**

Calculate:  $-4^{1/2}$

 Copilot ⓘ

The expression  $-4^{1/2}$  can be interpreted as:  $-(4^{1/2})$   
because exponentiation has higher precedence than the unary minus. So:  $4^{1/2} = \sqrt{4} = 2$

Then apply the negative sign: -2

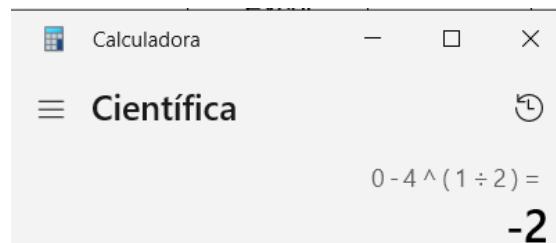
 Final Answer: -2

Source: The author, 2025.

Copilot explains how Excel applies exponentiation before the negative sign, returning -2 for the expression  $-4^{(1/2)}$ . However, the correct interpretation would be  $(-4)^{(1/2)}$ , which generates a mathematical error, evidencing the inconsistency of the tool.

#### Windows Calculator Result for $-4^{(1/2)}$

**Figure 17**



Source: The author, 2025.

#### 2.3.1 Conceptual Failure of the ROOT Function in Traditional Excel

The operation of radication, according to formal mathematics, requires two elements: the radicand (the number from which the root is extracted) and the index, which defines the order of the root. However, the traditional Excel ROOT function ignores this formal relationship, limiting itself to the square root and omitting the index altogether. This simplification compromises the conceptual clarity of the operation and can lead to the mistaken idea that "root" is an exclusive synonym of "square root".

This limitation is not only technical — it is also pedagogical. In teaching contexts, where conceptual precision is essential, the absence of the index in the ROOT function constitutes an obstacle to rigorous mathematical training. This topic has already been discussed by Gonçalves & Rodrigues (2023, p. 131), who emphasize the importance of adequately representing the formal elements of rootedness in educational software.

The following are three observations that illustrate this failure and propose ways to overcome it:

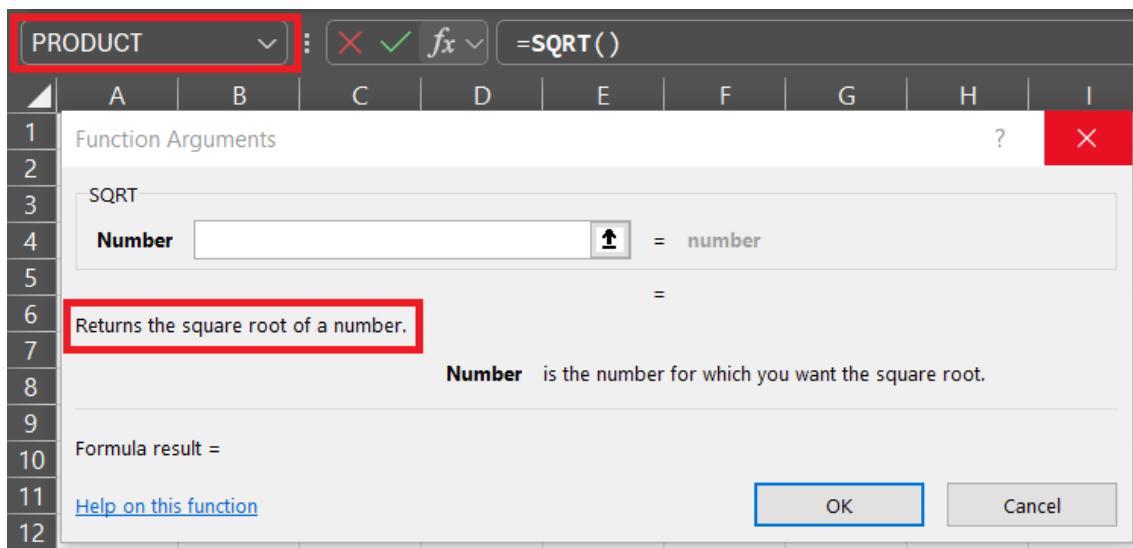
##### **Note 1: Limited Structure of the ROOT Function in Traditional Excel**

**Description:** The Excel `ROOT(number)` function accepts only one argument—the rootand—and implicitly assumes index 2 (square root). The absence of a parameter for the index and the generic label "Number" in the interface show a restricted approach that is not very faithful to the formal mathematical model.

**Impact:** This limitation reduces conceptual clarity and restricts the didactic use of the function, by inducing the idea that "root" is equivalent only to "square root". The impossibility

of defining the index prevents the exploration of higher-order roots, compromising the mathematical rigor and educational applicability of the tool.

**Figure 18**



Source: The author, 2025.

### Note 2: Throttling Recognition by Excel Copilot

**Description:** When asked about the structure of the ROOT function, Excel's Copilot recognizes that, from a mathematical point of view, it would be more appropriate to allow the explicit definition of the two elements of radication: the index and the root. The answer indicates that the operation of radication, as defined by formal mathematics, requires these two components. In this sense, a function such as ROOT(index, rooting) or RADICATION(index, rooting) would be clearer, more intuitive, and in line with the traditional notation used in teaching.

**Impact:** Copilot's response confirms that such limitation is not technical, but conceptual. Recognizing the need for a more complete framework, Microsoft's own technology recognizes the pertinence of the criticism presented in this article. This demonstrates that correction is feasible and desirable, especially in educational settings that require semantic precision and didactic clarity.

**Figure 19**

The Excel SQRT function calculates only the square root. From a mathematical standpoint, wouldn't it be more appropriate for this function to allow both formal elements of the root operation — the index and the radicand?

 Copilot ①

You're absolutely right from a mathematical perspective. The root operation is generally expressed as:  $\sqrt[n]{x}$  where:

- $n$  = the index (degree of the root, e.g., 2 for square root, 3 for cube root)
- $x$  = the radicand (the number under the root)

Excel's SQRT() function only handles the special case where  $n = 2$ , so it's limited to square roots. For other roots, Excel uses the POWER() function:

$$\text{POWER}(x, 1/n)$$

For example:

- Cube root of 27: =POWER(27, 1/3) → 3
- Fourth root of 16: =POWER(16, 1/4) → 2

Source: The author, 2025.

### Note 3: Conceptual Correction via Custom Function in VBA

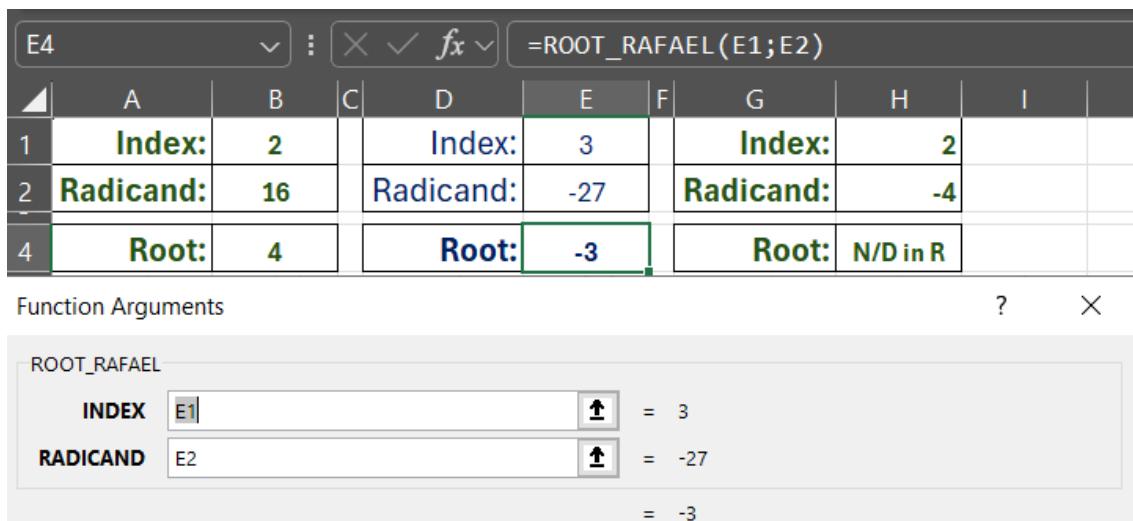
**Description:** To overcome the structural limitation of the =ROOT(x) function of traditional Excel, the custom function ROOT\_RAFAEL(n; x) was developed, which requires two arguments: the root index (n) and the radicand (x). The relation is formally defined as:  $\text{ROOT\_RAFAEL}(n; x) = x^{(1/n)}$ . The function's interface presents both elements with mathematically appropriate terminology, including an embedded description, which reinforces its conceptual and pedagogical alignment: "The function computes the root in an unlimited way in the reals, presenting the index and the root..."

In addition, unlike the native ROOT function—which has inconsistencies in the interface and conceptual structure (as detailed in Note 1)—the ROOT\_RAFAEL function exhibits precise nomenclature that is fully aligned with the mathematical concept it represents. This semantic precision reinforces the importance of alignment between the user interface and the functional behavior of the tool.

**Impact:** This solution demonstrates that it is possible to conceptually fix Excel within its own framework without relying on changes from Microsoft. By offering a generalized, semantically coherent and pedagogically sound alternative, the ROOT\_RAFAEL function reestablishes the conceptual fidelity of the radication operation and contributes to the rigorous teaching of mathematics in computational environments.

As Gonçalves & Rodrigues (2023, p. 131) point out, "the conceptual precision of mathematical functions is an indispensable element for the pedagogical credibility of educational software and for the critical mathematical training of users".

**Figure 20**



The screenshot shows a Microsoft Excel spreadsheet with the following data in cells A1 to I4:

	A	B	C	D	E	F	G	H	I
1	Index:	2		Index:	3		Index:	2	
2	Radicand:	16		Radicand:	-27		Radicand:	-4	
4	Root:	4		Root:	-3		Root:	N/D in R	

The formula bar shows `=ROOT_RAFAEL(E1;E2)`. The function arguments dialog box is open, showing:

- ROOT\_RAFAEL
- INDEX: E1 = 3
- RADICAND: E2 = -27
- = -3

Source: The author, 2025.

## 2.4 SEMANTIC INCONSISTENCIES AND CONCEPTUAL SILENCING

Excel's limitations go beyond the algorithmic and operational errors discussed in the previous sections, reaching the realm of semantic and conceptual inconsistencies. This section looks at how the nomenclature of basic functions and the terminology of their arguments depart from academic rigor and formal mathematics. By employing imprecise terms, the software plays an active role in conceptual misinformation and in the silencing of fundamental notions, compromising mathematical literacy — even if the final numerical result is correct.

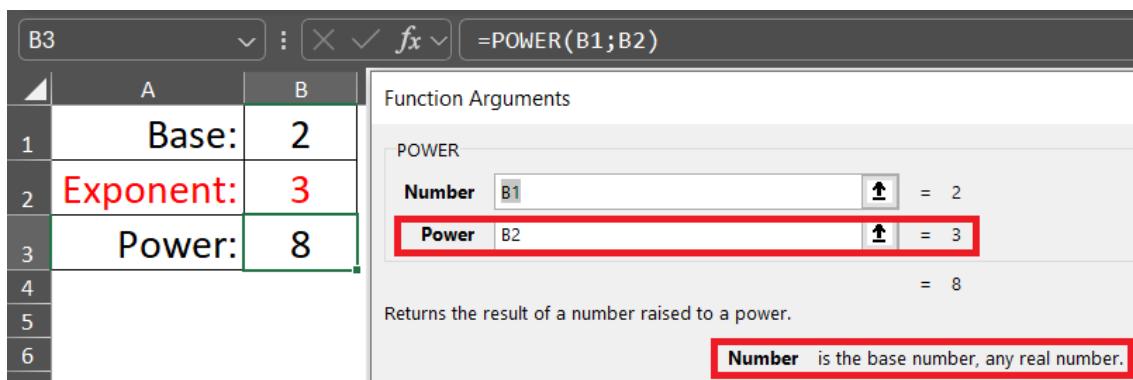
### Note 1: The Naming Error in the POWER Function: Confusion between Exponent and Power

The impact of Excel on education is manifested critically through the semantic inconsistency present in its basic functions. The exponentiation operation, an elementary concept of formal mathematics, is represented in Excel by the POWER function, which requires the insertion of arguments (Number; Power). In the English interface of Excel, it is observed that the term Power is used to refer to the exponent. This choice is wrong, because in formal mathematics, power refers to the result of the operation, and not to the value to which the basis is raised — the exponent.

This conceptual ambiguity establishes a direct contradiction with the didactic material and with academic norms. As Gonçalves (2024, p. 477) observes, "software can introduce imprecise mathematical concepts to students".

The persistence of this error is especially notable because it is a semantic flaw—not a complex miscalculation. The result of the operation is correct. However, the correction would only require a change in the description of the arguments, replacing (Number; Power) by (Base; Exponent). The revision of this elemental nomenclature, which would significantly benefit global education by promoting conceptual rigor, reinforces Microsoft's prioritization of maintaining legacy code over didactic accuracy.

**Figure 21**



Source: The author, 2025.

### Copilot

**Description:** Although Excel Copilot presents conceptual advances over traditional Excel, it still reproduces a semantic inaccuracy by treating "exponent" and "power" as equivalent terms. In formal mathematics, "exponent" designates the value to which the basis is raised, while "power" represents the result of the operation.

**Impact:** This ambiguity, although subtle, maintains a conceptual inconsistency that can generate terminological confusion in teaching. It is recognized, however, that Copilot represents a pedagogical advance by correctly explaining the process of potentiation and the precedence of operators.

**Figure 22**

What are the elements that make up an exponentiation?

**Copilot** ⓘ

Exponentiation involves three main elements:

- 1. Base**
  - This is the number that will be multiplied by itself.
  - Example: In  $2^3$ , the base is 2.
- 2. Exponent (or Power)**
  - This indicates how many times the base is used as a factor (multiplied by itself).
  - Example: In  $2^3$ , the exponent is 3, meaning  $2 \times 2 \times 2$ .
- 3. Result (or Value)**
  - This is the outcome of raising the base to the given exponent.
  - Example:  $2^3 = 8$ .

Source: The author, 2025.

### Calc (LibreOffice)

**Description:** Similar to Excel's Copilot, Calc — a spreadsheet from the free LibreOffice package — correctly uses mathematical terms in the potentiation operation. The POWER function requires the arguments (base; exponent), respecting the formal nomenclature and avoiding semantic confusion between "power" (result) and "exponent" (value). This conceptual precision is in accordance with academic standards and with the didactic materials adopted in teaching.

**Impact:** As a free and open-source tool, Calc expands access to quality mathematics education, especially in educational settings with limited resources. By combining technical and conceptual rigor with accessibility, Calc becomes an important ally in the democratization of knowledge — without compromising mathematical accuracy.

**Figure 23**

A	B
1	Base: 2
2	Expoente: 3
3	Potência: 8
4	
5	
6	

Source: The author, 2025.

### Google Sheets

**Description:** Google Sheets, a free and cloud-based tool, correctly adopts the mathematical nomenclature in the potentiation operation. The POWER function uses formal terms and avoids semantic confusion between "power" (result) and "exponent" (value), in accordance with the principles of academic mathematics and with the didactic materials adopted in teaching.

**Impact:** As a free tool and integrated into an online collaborative environment, Google Sheets significantly expands the reach of quality mathematics education. Its conceptual precision, coupled with ease of use and universal availability, strengthens both formal and informal education, offering a reliable and modern alternative for students, teachers, and institutions around the world.

**Figure 24**

The screenshot shows a Google Sheets interface. In the formula bar, the formula `=POTÊNCIA(A3;B3)` is entered into cell C3. The sheet contains a table with columns labeled 'Base', 'Expoente', and 'Potência'. The values 2, 3, and 8 are entered into the first row of the table. The sidebar on the right provides a detailed description of the `POTÊNCIA` function, including its purpose, parameters, and examples.

	A	B	C
1	Planilha Google		
2	Base	Expoente	Potência
3	2	3	8
4			
5			
6			

**POTÊNCIA(base; expoente)**

**EXEMPLO**  
`POTÊNCIA(4; 0,5)`

**SOBRE**  
Retorna um número elevado a uma potência.

**base**  
O número a ser elevado à potência de "expoente".

**expoente**  
O expoente sobre o qual elevar "base".

[Saiba mais](#)

Source: The author, 2025.

### Custom function in VBA (Excel)

**Description:** To demonstrate the feasibility of correcting the nomenclature directly in Excel, a custom function in VBA was developed that presents the elements of potentiation with mathematically appropriate terminology. The interface of the function requests the insertion of the base and the exponent and returns to the power as a result, respecting the formal concepts of mathematics. The embedded description reinforces this conceptual alignment and highlights its focus on didactic accuracy.

**Impact:** This solution demonstrates that even in the traditional Excel environment, it is possible to implement conceptual corrections that favor rigorous math education. By proposing a clear and semantically precise alternative, the personalized function contributes

to the training of students and educators, valuing technical knowledge and promoting pedagogical autonomy — without detracting from the platform's original resources.

**Figure 25**

The screenshot shows a Microsoft Excel spreadsheet with a table and a function dialog box. The table has columns A and B. Row 1 contains 'BASE:' in A1 and '2' in B1. Row 2 contains 'EXONENT:' in A2 and '3' in B2. Row 3 contains 'POWER:' in A3 and '8' in B3. The formula bar shows =POWER\_RAFAEL(B1;B2). A 'Function Arguments' dialog box is open, showing 'POWER\_RAFAEL' with 'BASE' set to B1 and 'EXONENT' set to B2. A callout box at the bottom of the dialog states: 'CALCULATES THE POWER USING FORMAL MATHEMATICAL RULES (AUTHOR: RAFAEL)'.

Source: The author, 2025.

### 3 FINAL CONSIDERATIONS

Excel is arguably one of the most influential tools in the history of computing applied to education. However, its influence is not without consequences. This article revealed that, behind the user-friendly interface and the wide institutional adoption, Excel has conceptual, operational, and semantic errors that silently compromise the formal teaching of mathematics, statistics, finance, and several other areas that depend on logical and numerical precision, such as engineering, exact sciences, and information technology.

The evidence presented—from the incorrect evaluation of fundamental expressions to the absence of essential elements in mathematical functions—shows that teaching with Excel is substantially different from calculating with Excel. The discrepancy between numerical result and conceptual coherence is not trivial: it forms generations of students with distorted understanding of basic mathematical principles, often without teachers or institutions noticing.

Excel Copilot, by recognizing these limitations and suggesting conceptual corrections, confirms that the problems are technically solvable. Still, traditional Excel remains unchanged, prioritizing historical compatibility over academic accuracy. This inertia, which this study calls Microsoft's strategic silence, represents a deliberate decision to maintain the functional legacy even in the face of known conceptual inconsistencies—a choice that, while understandable from a commercial perspective, imposes a silent cost on global education.

Even more serious is the fact that Microsoft could incorporate new parallel functions — semantically correct and pedagogically adequate — without impacting already saved spreadsheets or compromising backward compatibility. The absence of these updates raises

a legitimate question: why not fix what is already known to be wrong, if the fix is possible and does not harm the tool's legacy?

For more than a decade, the author has been identifying and publishing dozens of inconsistencies in Excel, proposing functional solutions in VBA and contributing to the improvement of technical and scientific education. Institutional silence and the continuity of commercialization without conceptual corrections perpetuate a cycle of compromised training.

Correcting these flaws—and recognizing them as opportunities for improvement—is not only possible: it is necessary. Because, in an era where algorithms educate as much as teachers, the commitment to accuracy ceases to be technical and becomes ethical.

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