

Decolonizing Mathematics Unveiling India's Foundational Contributions to Global Mathematical Heritage

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Abstract

The history of mathematics is often presented through a Eurocentric lens, overlooking the significant contributions of Indian intellectual traditions. Indian mathematics, deeply rooted in practical applications like astronomy and commerce, developed as a computational and algorithmic discipline. Foundational ideas, such as the decimal place-value system with zero and trigonometric functions, originated in India and were transmitted to the Islamic world and Europe, often without proper acknowledgment.

Indian mathematics, shaped by its philosophical traditions, prioritized computation, approximation, and practical reliability over axiomatic certainty. This approach, often misunderstood by Western historians, allowed for significant advancements in geometry, calculus, and number theory. Recognizing the Indian origins of mathematical concepts, challenges colonial narratives and highlights the importance of alternative epistemologies in shaping global knowledge.

Acknowledging the legacy of Indian mathematics is crucial for a more accurate and inclusive understanding of the subject.

Keywords: algorithmic methods, decimal place-value system, zero, trigonometric functions, astronomy, commerce, Śulba Sūtras, Jyotiṣa, Gaṇita, calculus, infinite series, number theory,

Introduction

The history of mathematics, as commonly presented in modern textbooks, is largely framed through a Eurocentric narrative that traces its origins from ancient Greece to Renaissance Europe and onward to modern Western science. This account, however, needs critical scrutiny. Infact, much of what is considered “modern mathematics” has deep roots in **Indian intellectual traditions**, particularly in Vedas, Śulba Sūtras, Jyotiṣa, Gaṇita, and **calculus-related methods developed in medieval Kerala**.

Now the need is to rethink **how mathematical knowledge is defined, transmitted, and legitimized**, and to question the colonial filters through which Indian knowledge systems have been interpreted.

Mathematics: A Cultural Practice, Not a Greek Invention

Mathematics is not a culture-neutral, universally identical activity, but rather a practice embedded in specific civilizational contexts. Indian mathematics developed not as an abstract, axiomatic enterprise divorced from application—as in post-Euclidean Western traditions—but as a computational, algorithmic, and pragmatic discipline closely tied to astronomy (Jyotiṣa), ritual geometry, calendrical calculations, navigation, and commerce.

Not only did India contribute to mathematics, but many foundational ideas of mathematics originated in India, were transmitted to the Islamic world, and later entered Europe—often without acknowledgment and with substantial reinterpretation.

Mathematics as Practical Knowledge in Indian Civilization

Mathematics in India is profoundly influenced by philosophical assumptions, metaphysical commitments, and the practical requirements of civilizations.

Indian mathematics primarily developed as practical, algorithmic, and application-oriented knowledge, rather than as an abstract, axiomatic system. This orientation is evident in various domains, including:

- Astronomy (Jyotiṣa)
- Calendar computation and time-keeping
- Architecture and measurement (Śulba Sūtras)
- Commerce, land measurement, and taxation

Indian mathematicians prioritized obtaining accurate results efficiently over proving theorems in the Greek axiomatic manner. Procedures (vidhi), rules (sūtra), and computational techniques were esteemed over metaphysical speculation. This pragmatic approach resulted in remarkable advancements in arithmetic, algebra, geometry, trigonometry, and infinite series.

The Place-Value System and Zero: A Pivotal Contribution to Indian Mathematics

One of the most significant contributions of Indian mathematics is the decimal place-value system with zero. This system is not merely a trivial invention but reflects a sophisticated understanding of number representation and abstraction.

While European histories often portray zero as a late and accidental discovery, Indian texts—both mathematical and philosophical—demonstrate a profound engagement with the concept of śūnya. The Indian zero was not merely a placeholder; it was integrated into computation, algebraic manipulation, and numerical reasoning centuries before its adoption in Europe.

The transmission of this system through Arabic scholars into Europe fundamentally transformed mathematics there, facilitating the emergence of modern science.

As noted by German Indologist Schlegel (1772–1829), “Next to letters, the most important of human discoveries is the invention of the decimal ciphers.” Similarly, Albert Einstein emphasized the profound indebtedness of humanity to Indians for their teaching of counting, without which no worthwhile scientific discovery could have been achieved.

The invention of zero stands as a singular contribution of India to the modern world of science and technology. It has revolutionized every aspect of science and technology. Renowned mathematician G.B. Halsted (1912:20) succinctly described the significance of zero as follows:

“The importance of the creation of zero mark can never be exaggerated. This giving to airy nothing, not merely a local habitation and a name, a picture, a symbol, but helpful power, is the characteristic of the Hindu race from which it sprang. It is akin to coining Nirvana into dynamos. No single mathematical creation has been more potent for the general advancement of intelligence and power.”

Laplace (Ifrah, 2000) further underscores the transformative power of zero, stating:

“The ingenious method of expressing all numbers using ten symbols, each with a value of position and absolute value, originated in India. While its simplicity may seem evident today, its profound significance and importance are often overlooked. The simplicity of this system lies in its ability to facilitate calculations and elevate arithmetic to a position of utility. Its importance is further underscored by the fact that it surpassed the achievements of two of antiquity’s greatest mathematicians, Archimedes and Apollonius.”

This challenges the prevailing notion that “true mathematics” must adhere to the Greek axiomatic-deductive model exemplified by Euclid. Axiomatic proof was neither the sole nor most effective method of mathematical inquiry, and Indian mathematicians consciously prioritized accurate computation, approximation, and practical reliability over metaphysical certainty.

Indian Numerals, Zero, and the Algorithmic Revolution

The invention of numerals and zero did not merely represent a numerical convenience but also catalyzed an algorithmic revolution that rendered large-scale computation feasible.

Without the introduction of Indian numerals, the development of modern arithmetic, algebra, accounting, astronomy, and eventually calculus and computation would have been virtually impossible.

Although European adoption of this system occurred through Arabic intermediaries, its Indian origin is unequivocal. European mathematics experienced rapid advancement only after abandoning Roman numerals and assimilating Indian computational techniques, often without explicit acknowledgment.

For instance, Roman numerals rendered the mathematical functions of division and multiplication, among others, virtually inaccessible.

Trigonometry and Astronomy: Indian Foundations

Trigonometry has its roots in India. The Indian origin of trigonometric functions, particularly sine (jya), cosine (kojya), and related tables is indisputable. In contrast to Greek chord-based trigonometry, Indian trigonometry exhibited the following characteristics:

- Function-based rather than geometric
- Close association with astronomical observation

- Numerical expression, not geometric representation

This functional approach is more aligned with contemporary mathematics compared to Greek geometry. The Indian sine tables, meticulously developed for precise astronomical calculations, were subsequently assimilated into Islamic astronomy and subsequently Latin Europe, often under modified names and without recognition of their Indian origin.

Calculus before Newton: The Kerala School

The Kerala School of Mathematics (approximately 14th–16th centuries), associated with scholars such as Mādhava of Saṅgamagrāma, Nīlakaṇṭha Somayāji, Jyesthadeva, and others, pioneered the development of calculus.

Their notable achievements include:

Infinite series expansions for sine, cosine, and arctangent.

Precise computation of π to multiple decimal places.

Error analysis and convergence techniques.

A functional comprehension of differentiation and integration.

These accomplishments constitute calculus in all but its nomenclature, having been developed centuries before Newton and Leibniz.

These were not isolated curiosities but integral components of a systematic mathematical tradition. These ideas likely traversed to Europe through Jesuit missionaries, contributing—directly or indirectly—to the subsequent development of calculus in Europe, where they were subsequently re-formulated in an axiomatic framework.

In contrast to European calculus, which grappled with philosophical quandaries pertaining to infinity and rigor, Indian calculus was computational, approximate, and result-oriented, making it more suitable for astronomical and navigational endeavors.

According to Professor C.K. Raju, the present-day difficulties in teaching calculus are rooted in the concepts of real numbers and limits. These concepts were developed long after the purported discovery of calculus by Newton and Leibniz. This is because Europeans recognized their own lack of a comprehensive understanding of calculus.

How did Newton and Leibniz discover calculus without comprehending it? It is believed that they acquired the knowledge from India, specifically in relation to their navigational challenges, and did not acknowledge the source of their learning. This revelation has significant implications for teaching calculus, as knowledge thieves often fail to grasp the true nature of what they acquire.

While the West may have failed to grasp the Indian epistemology of calculus, it holds the misconception that it engaged in a superior form of mathematics, as exemplified by the racist terminology associated with the ‘Pythagorean theorem’. However, contrary to these prevalent myths, the actual proof presented in Euclid’s book employs the same principles of proof as its Indian counterpart. This is because, contrary to the misconception, axiomatic proofs are not explicitly found in the Euclid book. In fact, the invention of real numbers was necessitated by the fact that even the first proposition of the Euclid book lacked an axiomatic proof.”

The Śulba Sūtras and Early Indian Geometry

Long before Euclid (c. 300 BCE), the Śulba Sūtras (c. 800–500 BCE) formulated sophisticated geometric principles for altar construction. These texts encompass:

Accurate statements equivalent to the Pythagorean theorem.

Geometric methods for approximating the area of a circle.

Explicit use of irrational quantities.

Practical constructions utilizing cords and pegs.

These insights were not accidental or primitive but integral to a systematic geometric tradition, developed independently of Greek influence. Unlike Greek geometry, which idealized abstract figures, Śulba geometry was operational and rooted in real-world construction, which explains its tolerance for approximation—a feature often misinterpreted as “lack of rigor” by subsequent Western historians.

Commonly, it is asserted that “true mathematics” must adhere to the Greek axiomatic-deductive model exemplified by Euclid. However, axiomatic proof was neither the sole nor most effective method of mathematical inquiry. Consequently, Indian mathematicians consciously prioritized accurate computation, approximation, and practical reliability over metaphysical certainty.

Philosophical Foundations: Indian Logic and Epistemology

Indian mathematics was profoundly influenced by its philosophical and epistemological underpinnings. Indian mathematical practice was guided by Indian philosophical schools that prioritized:

Empirical verification (pratyakṣa): The verification of mathematical truths through empirical observation.

- **Practical success (vyavahāra):** The practical applicability and usefulness of mathematical concepts.
- **Contextual validity:** The recognition that mathematical truths may vary depending on the context.

These principles stand in stark contrast to the Greek emphasis on axiomatic certainty and metaphysical abstraction. European insistence on deductive proof eventually led to foundational crises in mathematics. In contrast, Indian mathematics avoided such crises by maintaining its grounding in practical applicability.

Proof, Rigor, and the Colonial Reinterpretation of Indian Mathematics

It is a surprising fact that the terms “proof” and “rigor” have been retrospectively imposed as criteria to evaluate Indian mathematics. While Indian mathematicians employed empirical verification, iterative correction, and pragmatic validation, proof was often implicit, procedural, or algorithmic. Furthermore, the Western emphasis on formal axioms stemmed from theological concerns about certainty rather than mathematical necessity.

Colonial historians, influenced by missionary and imperial agendas, misinterpreted Indian methods as inferior due to their lack of resemblance to Euclidean geometry. Judging one epistemology by the standards of another is illogical.

Mathematics, Philosophy, and Indian Epistemology

Indian mathematics is intrinsically linked to Indian philosophy. Concepts such as:

- * Ananta (infinity)
- * Śūnya (zero, void, potentiality)
- * Kāla (time as cyclic)

Shaped mathematical imagination in fundamentally distinct ways from Greek metaphysics. Indian acceptance of infinity and infinitesimals made the development of series and limits conceptually natural.

This approach also addresses the astonishment expressed by Al-Biruni regarding the vast numbers employed by Indians.

Having examined the names of the numerical orders across diverse languages and cultures, Al-Biruni criticized Hindus for their ardent interest in large numbers. He observed:

“I have studied the denotations of the numerical orders in various languages with all the individuals I have encountered, and I have discovered that no nation surpasses the thousand. The Arabs, too, cease at the thousand, which is undoubtedly the most accurate and natural approach. However, those who venture beyond the thousand in their numerical system are the Hindus, at least in their technical arithmetical terms.”

Arabs, Greeks, and Romans lacked knowledge of the decimal system and place value notation, rendering them incapable of utilizing large numbers.

The Greeks employed the term “myriad” (10^4) as the limit of counting, while the Romans defined “mille” (10^3) as the largest number.

In contrast, Indians, who pioneered the decimal system, utilized numbers without any apparent limit. Even the Yajurveda employed numbers up to “praradha” (10^{17}).

This philosophical foundation and familiarity with zero and the decimal system explain why Indian mathematicians confidently manipulated infinite processes, devoid of the metaphysical anxiety that plagued European thinkers until the 19th century.

Colonial Historiography and the Erasure of Indian Contributions

Colonial-era historiography systematically minimized or erased non-European contributions to science and mathematics. British colonial education policies reinforced the notion that Indians were merely recipients, not originators, of mathematical knowledge.

This narrative was not accidental but served ideological purposes—justifying colonial rule and intellectual dependency. Recovering the Indian origin of mathematics is therefore not merely an academic exercise but a necessary step toward decolonizing knowledge systems.

If we restore the Indian origin of key mathematical ideas, it would help us:

- Restore historical accuracy,

- Challenge inherited intellectual hierarchies,
- Encourage alternative approaches to teaching mathematics today.

For India in particular, it also serves a deeper purpose: reclaiming confidence in its own intellectual traditions and recognizing that scientific rationality and mathematical sophistication were indigenous, not imported.

Relevance for the Modern World

Recognizing the Indian origin of key mathematical ideas has profound implications:

- It challenges the myth of cultural superiority in science,
- It encourages pluralistic approaches to knowledge,
- It validates alternative epistemologies and methodologies,
- It restores intellectual confidence in non-Western traditions.

There is no need for rethinking the foundations of modern mathematics. Learning from Indian methods that prioritized computation, approximation, and real-world application—qualities increasingly important in the age of computers and numerical simulation—is valuable.

Conclusion

It is imperative to critically reevaluate deeply ingrained assumptions regarding the historical and fundamental nature of mathematics. Indian mathematics was not merely derivative or primitive; it was innovative, sophisticated, and foundational. From the development of the decimal system and the concept of zero to the advancement of trigonometry and infinite series, India played a pivotal role in shaping global mathematical knowledge.

Recognizing this legacy is not an expression of cultural pride alone, but a crucial step towards a more precise, inclusive, and philosophically honest comprehension of mathematics itself. The trajectory of future mathematical thought may hinge on the recovery of the wisdom of its past—particularly the extensive and frequently overlooked traditions of India.

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