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Indian mathematics in the classroom: Śulbasūtra geometry, Āryabhaṭan algorithms and the Kerala school in contemporary pedagogy under NEP 2020

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Abstract
The National Education Policy 2020 directs Indian institutions to integrate Indian Knowledge Systems (IKS) across the curriculum in "an accurate and scientific manner," and it names mathematics among the domains in which India's contributions have been foundational. This article asks what a historically responsible and pedagogically effective integration of the Indian mathematical tradition into school and undergraduate teaching would look like. It surveys three exemplary strata of that tradition on the basis of mainstream history-of-mathematics scholarship: the śulbasūtra corpus (c. 800-200 BCE), with its constructive altar geometry, its general statement of the diagonal ("Pythagorean") rule, and its remarkably accurate rational approximation to √2; the classical siddhānta tradition from Āryabhaṭa (499 CE) through Brahmagupta and Bhāskara II, encompassing decimal place-value arithmetic, the algebra of zero and negatives, root-extraction algorithms, the kuṭṭaka method for linear indeterminate equations, and the pedagogical artistry of the Līlāvatī; and the Kerala school (14th-16th centuries), whose infinite series for π, sine, and cosine, together with the demonstrative exposition of the Yuktibhāṣā, anticipate central elements of calculus. The article then proposes concrete classroom modules aligned with the National Curriculum Framework for School Education 2023 and IKS credit courses, framed by ethnomathematics and history-in-mathematics-education research. Throughout, it insists on scholarly caution: distinguishing the historical tradition from twentieth-century "Vedic Mathematics," acknowledging unresolved questions of transmission, and avoiding chauvinistic overclaiming. Historical fidelity, it argues, is not an obstacle to pride in the tradition but its only durable foundation.

Keywords: Indian Knowledge Systems, history of mathematics, śulbasūtra, Āryabhaṭa, Kerala school, NEP 2020

1. Introduction

The National Education Policy 2020 (NEP 2020) marks the first time in independent India's policy history that the integration of Indian Knowledge Systems (IKS) into mainstream education has been articulated as an explicit, system-wide mandate. The policy declares that "the rich heritage of ancient and eternal Indian knowledge and thought" is a guiding principle, and it specifically envisages that Indian contributions to knowledge-including mathematics, astronomy, medicine, and linguistics-be incorporated "in an accurate and scientific manner" wherever relevant across the curriculum (Ministry of Human Resource Development [MHRD], 2020, paras. 4.23, 4.27) [13]. Mathematics occupies a special place in this vision, both because the policy elsewhere emphasizes mathematical and computational thinking as foundational for India's future, and because the Indian mathematical tradition is, by any sober scholarly reckoning, among the major mathematical cultures of the premodern world (Plofker, 2009; Joseph, 2011) [10, 15].

Yet the classroom integration of this tradition confronts a double problem. The first is neglect: standard school and undergraduate mathematics curricula in India have historically presented the subject as an essentially European inheritance, with Indian material confined to a passing mention of "Indian numerals" or a portrait of Śrīnivāsa Rāmānujan. Generations of Indian students have learned the theorem of the diagonal as "Pythagoras' theorem" without ever hearing that a general statement of the same relation appears in the Baudhāyana-śulbasūtra, or learned calculus without knowing that power series for the sine and the arctangent were derived in Kerala more than two centuries before Newton and Leibniz (Katz, 1995; Plofker, 2009) [11, 15]. The second problem is the mirror image of the first: an unscholarly popularization that inflates, garbles, or simply invents Indian achievements-most visibly in the twentieth-century system marketed as "Vedic Mathematics," which

professional mathematicians and historians have shown to be neither Vedic nor, in any historically meaningful sense, a recovery of ancient mathematics (Dani, 1993) [4]. Between the Scylla of colonial-era erasure and the Charybdis of chauvinistic overclaiming lies the narrow but well-charted channel of mainstream history of mathematics, built over more than a century of philological and mathematical scholarship from Datta and Singh (1935/1962) [5] and Sarasvati Amma (1979) [18] to Plofker (2009) [15], Divakaran (2018) [6], and the critical editions and translations of the Kerala corpus (Sarma, 2008; Ramasubramanian & Sriram, 2011) [19, 17].

This article argues that navigating this channel is not merely an ethical obligation but a pedagogical opportunity. The Indian mathematical tradition is unusually well suited to classroom use precisely because of its characteristic forms: constructive and verifiable geometry performed with cord and stakes; efficient algorithms articulated in compact verse; word problems embedded in vivid natural and social imagery; and, in the Kerala school, systematic demonstrations (yukti) that model mathematical justification. The aims of the article are threefold: (a) to present, on the authority of mainstream scholarship, an accurate synoptic account of three strata of the Indian tradition-śulbasūtra geometry, the classical siddhānta tradition from Āryabhaṭa to Bhāskara II, and the Kerala school; (b) to translate this material into concrete, curriculum-aligned pedagogical modules under NEP 2020 and the National Curriculum Framework for School Education 2023 (NCF-SE 2023); and (c) to articulate the cautions-historiographical, pedagogical, and institutional-without which IKS integration risks discrediting itself. The article is addressed to mathematics educators, teacher-education institutions, and designers of IKS credit courses in higher education.

2. Geometry with Cord and Stake: The Śulbasūtra Corpus

The oldest stratum of Indian mathematical literature that survives as connected mathematical text is the śulbasūtra corpus-manuals of altar construction attached, as part of the kalpa (ritual procedure) literature, to the various Vedic schools. The principal texts bear the names of Baudhāyana, Āpastamba, Mānava, and Kātyāyana, and are conventionally dated on linguistic and textual grounds to roughly 800-200 BCE, with Baudhāyana's generally regarded as the earliest (Sen & Bag, 1983; Plofker, 2009) [15, 20]. The word śulba means "cord": the geometry of these texts is the geometry of the stretched rope and the fixed stake, developed for the practical purpose of laying out the vedi (sacrificial ground) and the agni (fire altar) in prescribed shapes and prescribed areas. It is, in Sarasvati Amma's (1979) [18] phrase, a geometry that is applied, constructive, and verifiable: every proposition corresponds to a procedure that can be carried out on the ground and checked by measurement.

The most celebrated statement in the corpus is the general rule of the diagonal. The Baudhāyana-śulbasūtra states: "The cord [stretched] along the diagonal of an oblong produces both [areas] which the cords along the longer and the shorter side produce separately" (Baudhāyana-śulbasūtra 1.12; Sen & Bag, 1983) [20]. This is a fully general statement, for arbitrary rectangles, of the relation now universally taught as the Pythagorean theorem; the texts also list specific "Pythagorean triples" such as (3, 4, 5), (5, 12, 13), (8, 15, 17), and (12, 35, 37) used in practical layout (Datta & Singh, 1935/1962; Plofker, 2009) [5, 15]. Historians are careful on two points that the classroom should preserve. First, the śulbasūtra statement is a rule asserted and applied, not a deductive proof in the Euclidean sense; the texts do not tell us how the rule was discovered or justified. Second, comparable knowledge of the relation-at least in the form of triples and applications-existed in Old Babylonian mathematics a millennium earlier, so the responsible claim is not one of absolute global priority but of independent, early, and general articulation within Indian ritual geometry (Plofker, 2009; Joseph, 2011) [10, 15]. Precisely so framed, the material remains striking: students learn that the "Pythagorean" relation was part of the working knowledge of Indian altar builders centuries before Pythagoras, and that naming conventions in mathematics record European historiography rather than historical fact.

Around this central rule the śulbasūtras develop a substantial toolkit of area-preserving transformations: constructing a square equal in area to the sum or difference of two given squares; transforming a rectangle into a square of equal area and conversely; and approximate constructions relating the circle and the square, required because certain altars of different shapes had to have the same area of seven and a half square puruṣas (Sarasvati Amma, 1979; Sen & Bag, 1983) [18, 20]. The circle-square constructions embody implicit approximations to π; the "circulature" rule of Baudhāyana corresponds to a value of about 3.088, and the texts show awareness that such constructions are approximate (anitya), a distinction between exact and approximate results that is itself of pedagogical interest (Plofker, 2009) [15].

Most remarkable is the rational approximation to the square root of two, needed to construct a square of double a given area via the diagonal. Baudhāyana (and, in nearly identical words, Āpastamba and Kātyāyana) prescribes: increase the measure by its third, and this third by its own fourth, less the thirty-fourth part of that fourth. Symbolically,

$$\sqrt{2} \approx 1 + 1/3 + 1/(3\cdot4) - 1/(3\cdot4\cdot34) = 577/408 \approx 1.4142157,$$

correct to about five decimal places (Baudhāyana-śulbasūtra 2.12; Datta & Singh, 1935/1962; Plofker, 2009) [5, 15]. The texts add the significant qualifier saviśeṣa-"with a remainder," or "with something left over"-indicating awareness that the value is not exact. How the value was obtained is not stated, and several plausible reconstructions (geometric dissection; iterated side-and-diagonal reasoning) exist in the literature; the honest classroom presentation offers these as reconstructions, not facts (Sen & Bag, 1983; Divakaran, 2018) [6, 20].

It is worth pausing on what the śulbasūtra corpus teaches about the character of early Indian mathematics. The geometry did not arise as contemplation of ideal form but as the solution of exacting practical constraints: the śyenaciti (falcon-shaped altar) had to be assembled from bricks of prescribed shapes into a prescribed total area, and successive constructions of the altar required enlarging the area while preserving the shape-a problem of similarity and scaling solved by systematic procedures (Sarasvati Amma, 1979) [18]. The corpus therefore embodies a complete cycle that modern pedagogy labors to reconstruct artificially: a genuine problem, a constructive method, an executed artifact, and an empirical check. It also demonstrates that "applied" origins are no bar to theoretical depth, since the same texts that specify brick counts also state the general

diagonal rule and the saviśeṣa approximation to √2.

The pedagogical potential of this corpus is immediate. Rope-and-peg constructions require no apparatus beyond cord, stakes, and open ground; they convert the middle-school geometry syllabus-perpendiculars, squares, area, the theorem of the diagonal, similar figures-into embodied, cooperative, outdoor activity. A student who has physically laid out a (5, 12, 13) right angle with a knotted cord, or transformed a rectangle into a square of equal area by the Baudhāyana procedure and verified the areas by counting unit squares, possesses a kind of understanding that symbolic manipulation alone rarely produces. Section 6 develops this into a structured module.

3. The Decimal Place-Value System, Zero, and the Historicity of Numeration

If one contribution of Indian mathematics is universally acknowledged, it is the decimal place-value system with zero-the numeration in which the entire world now calculates. The mainstream scholarly account, which the classroom should present carefully, runs as follows. Decimal number words are as old as the Ṛgveda, and named powers of ten to very large orders are a persistent feature of Sanskrit literature. Place-value notation-in which digit position, not symbol, carries the power of ten-is attested in India by the early centuries CE and is fully presupposed by Āryabhaṭa's arithmetic in 499 CE; a decimal place-value system with a zero placeholder is described as standard by the seventh century, when Brahmagupta treats zero as a number in its own right (Datta & Singh, 1935/1962; Plofker, 2009) [5, 15]. The Bakhshālī manuscript, a birch-bark mathematical text from the northwest of the subcontinent, uses a dot for zero; its dating has been debated, and recent radiocarbon results announcing very early dates for some folios have themselves been contested by specialists, so the prudent classroom claim is a range within roughly the third to seventh centuries CE rather than a sensational headline (Hayashi, 1995; Plofker *et al*., 2017) [8, 16]. The earliest securely dated inscriptional zero in India in a decimal place-value context is conventionally cited from the Gwalior inscriptions of 876 CE, with earlier Southeast Asian inscriptions in Indian-derived numeration also attested (Plofker, 2009) [15].

The conceptual leap that historians emphasize is not the placeholder alone-Babylonian scribes had a placeholder in base sixty-but the arithmetization of zero and of negative quantities as objects of calculation. Brahmagupta's Brāhmasphuṭasiddhānta (628 CE) states explicit rules: the sum of a positive and a negative is their difference; the sum of two negatives is negative; zero added to or subtracted from a quantity leaves it unchanged; the product of a negative and a positive is negative, of two negatives positive; zero times anything is zero (Brāhmasphuṭasiddhānta 18.30-35; Plofker, 2009) [15]. Brahmagupta stumbles, instructively, at division by zero, and Bhāskara II's later attempt to work with the quantity khahara (that which has zero as divisor) shows the tradition wrestling with what would only be clarified by the modern concepts of limits and undefined operations (Datta & Singh, 1935/1962; Divakaran, 2018) [5, 6]. For students, this is a profound lesson: even the rules of signs, presented in textbooks as trivial conventions, were hard-won conceptual achievements with a history, a geography, and unfinished edges.

The transmission history is equally teachable and, unlike some other transmission questions, well documented. Indian numeration and calculation methods passed to the Islamic world, where al-Khwārizmī of Baghdad composed, around 825 CE, a treatise on calculation with the Hindu numerals; surviving in Latin translation, it made "Algoritmi"-the Latinized form of its author's name-the eponym of the modern word algorithm, while the Arabic title of his algebra gave Europe the word itself (Joseph, 2011; Katz, 1995) [11, 10]. The numerals entered Europe as figurae Indorum or "Arabic numerals" and displaced Roman numeration over centuries of commercial arithmetic. The pedagogical value of teaching this historicity is twofold. First, it corrects the silent default by which mathematics appears culturally unmarked and hence implicitly European: the very digits on the blackboard are artifacts of a Indian-Islamic-European transmission chain. Second, comparing numeration systems-Roman additive notation, Babylonian base sixty, the Sanskrit bhūtasaṃkhyā word-numerals and the kaṭapayādi consonant encoding used in Kerala-makes the design of the place-value system visible as a design, whose efficiency for algorithmic computation students can rediscover by attempting long multiplication in Roman numerals (Joseph, 2011; Sarma, 2008) [10, 19].

4. Āryabhaṭa, the Siddhānta Tradition, and the Pedagogy of the Līlāvatī

The classical period of Indian mathematics unfolds within astronomy. The Āryabhaṭīya, composed by Āryabhaṭa in 499 CE at the age of twenty-three, is a work of 121 verses in four chapters, of which the Gaṇitapāda (chapter on computation) compresses an entire mathematical curriculum into thirty-three verses (Shukla & Sarma, 1976; Plofker, 2009) [21, 15]. Its algorithms presuppose and exploit decimal place value. The rules for extracting square roots and cube roots (Āryabhaṭīya, Gaṇitapāda 4-5) proceed digit by digit through the decimal expansion-essentially the algorithms taught in Indian schools into living memory-and are among the earliest explicit statements of place-value root extraction anywhere (Datta & Singh, 1935/1962; Plofker, 2009) [5, 15]. The Gaṇitapāda also gives series summations, rules for arithmetic progressions, an accurate value of π as 62,832/20,000 = 3.1416, described as āsanna, "approaching" (i.e., approximate) (Āryabhaṭīya, Gaṇitapāda 10)-another instance of the tradition's care about exactness-and the construction of the sine table.

Two items deserve particular attention for teaching. The first is trigonometry itself. Indian astronomers replaced the Greek chord with the half-chord, jyā or jīvā-the sine in all but name-and tabulated sine differences at intervals of 3°45′ (Āryabhaṭīya, Gītikāpāda 12; Plofker, 2009) [15]. The etymological journey of the word is a classroom delight: Sanskrit jīvā was transliterated into Arabic as jyb, misread as jayb ("pocket, fold"), and translated into Latin as sinus-whence "sine." Few episodes demonstrate so vividly that mathematics is a multilingual, multicultural inheritance. The second item is the kuṭṭaka ("pulverizer"), Āryabhaṭa's method for solving linear indeterminate equations of the form ax + c = by in integers (Āryabhaṭīya, Gaṇitapāda 32-33), arising in astronomy from the need to compute planetary cycles from remainders. The verses are terse to the point of obscurity, and it is Bhāskara I's commentary of 629 CE that supplies worked examples and exposition (Keller, 2006) [12]. The kuṭṭaka is mathematically equivalent to the extended Euclidean algorithm and to the solution of linear

congruences, and its later elaborations by Brahmagupta and Bhāskara II-including Brahmagupta's composition method (bhāvanā) and the cakravāla (cyclic) method for the so-called Pell equation, brought to completion by Jayadeva and Bhāskara II-constitute a genuine Indian tradition of algorithmic number theory of the first rank (Datta & Singh, 1935/1962; Plofker, 2009; Divakaran, 2018) [5, 15, 6].

The tradition culminates, for pedagogical purposes, in Bhāskara II (b. 1114 CE), whose Līlāvatī (arithmetic and geometry) and Bījagaṇita (algebra) became the standard mathematical textbooks of the subcontinent for centuries, generating an enormous commentarial literature and translations into Persian at the Mughal court (Plofker, 2009) [15]. The Līlāvatī is a pedagogical masterpiece in a precise sense: it teaches through problem-poems. A rule is stated in compact verse; it is then exercised through problems addressed affectionately to a student ("O doe-eyed one," "O friend") and clothed in scenes of bees among lotuses, swans on lakes, peacocks and snakes, pearls scattered from a necklace, armies and elephants. A famous example: from a bunch of lotuses, one-third were offered to Śiva, one-fifth to Viṣṇu, one-sixth to the Sun, one-quarter to the Goddess, and the remaining six to the guru-how many lotuses were there? The mathematical content is a linear equation; the packaging is memory-friendly, culturally resonant, and affectively warm. Modern mathematics education research recognizes exactly these features-narrative context, affect, and rhythmic language-as supports for engagement and retention in word-problem solving. The tradition of teaching mathematics through verse and story is thus not a quaint curiosity but a tested pedagogical technology, and Section 6 proposes its direct reuse.

Bhāskara II's algebraic writings also display a sophisticated handling of the objects that school algebra treats as routine. The Bījagaṇita works systematically with negative quantities (marked with a dot, and interpreted where needed as debts or reversed directions), with several unknown colors (varṇa) as symbols for multiple unknowns, and with surds; and Bhāskara's discussions of quadratic problems note the existence of two roots and the conditions under which a root must be rejected as inapplicable to the problem's conditions-an early instance of the modeling judgment that curricula now try to cultivate under the heading of interpreting solutions in context (Datta & Singh, 1935/1962; Plofker, 2009) [5, 15].

Two register-setting observations complete this section. First, the siddhānta tradition operated through a characteristic textual ecology: terse root verses (sūtra/kārikā) transmitted with expansive prose commentaries (bhāṣya, vyākhyā) containing examples, derivations, and upapatti or yukti (justification). The old canard that Indian mathematics gave rules without reasons does not survive acquaintance with this commentarial literature (Keller, 2006; Sarma, 2008; Divakaran, 2018) [12, 19, 6]. Second, the tradition's demonstrative standards differ from Euclid's axiomatic-deductive format; they are closer to what modern mathematicians would recognize as derivations and convincing arguments, often geometric or algebraic verifications. Teaching students that there is more than one historical style of mathematical justification-and letting them evaluate an upapatti on its merits-is itself an education in the philosophy of mathematics.

5. The Kerala School: Infinite Series, Yukti, and the Question of Calculus

Between the fourteenth and sixteenth centuries, a lineage of astronomer-mathematicians working in the Nila river region of Kerala produced what mainstream historiography now recognizes as the most advanced mathematics of the premodern world in its domain: the theory of infinite series for the circle and the trigonometric functions (Katz, 1995; Plofker, 2009; Divakaran, 2018) [11, 15, 6]. The founder, Mādhava of Saṅgamagrāma (c. 1340-1425), is credited by his successors with the series that Western textbooks name after Leibniz and Gregory:

$$\pi/4 = 1 - 1/3 + 1/5 - 1/7 + \cdots,$$

together with the general arctangent series, and with power series for sine and cosine equivalent to $\sin\theta = \theta - \theta^3/3! + \theta^5/5! - \cdots$ and $\cos\theta = 1 - \theta^2/2! + \theta^4/4! - \cdots$ (Plofker, 2009; Ramasubramanian & Sriram, 2011) [15, 17]. Because the π series converges impractically slowly, Mādhava also devised rational end-correction terms that accelerate convergence dramatically-an early exercise in what would now be called asymptotic error estimation-and transformed series converging much faster; a value of π correct to eleven decimal places is transmitted in his name in a kaṭapayādi-encoded verse (Sarma, 2008; Plofker, 2009) [19, 15]. Little of Mādhava's own writing on these matters survives; our knowledge comes through his school: Parameśvara, Nīlakaṇṭha Somayājī-whose Tantrasaṅgraha (1500 CE) systematized the astronomy and whose Āryabhaṭīyabhāṣya contains penetrating mathematical discussions, including a strikingly clear statement of the irrationality-flavored claim that the ratio of circumference to diameter cannot be exactly stated (Ramasubramanian & Sriram, 2011) [17]-and Jyeṣṭhadeva, whose Yuktibhāṣā (c. 1530) is the key document for pedagogy.

The Yuktibhāṣā ("exposition of rationales"), composed in Malayalam prose rather than Sanskrit verse, is precisely what its title announces: a sustained, step-by-step demonstration of the school's results, from the rule of three up through the derivation of the π and sine series (Sarma, 2008) [19]. The derivations proceed by dividing an arc into ever smaller equal parts, estimating each piece by similar triangles, summing the resulting expressions using rules for sums of integer powers (with explicit recognition that, for large n, the sum of k-th powers behaves like n^(k+1)/(k+1)), and passing to the limit as the subdivision is refined. In modern terms, the Yuktibhāṣā performs discrete integration and term-by-term limiting arguments; in Katz's (1995) [11] careful formulation, the Kerala mathematicians "had developed many of the ideas of calculus"-infinite series, term-wise integration of power series in special cases, and interconversion of arc and chord equivalent to differential relations for sine and cosine-without, however, assembling them into a general theory of differentiation and integration applicable to arbitrary functions, and without the concept of a function itself. The responsible classroom formulation is therefore anticipation of central elements of calculus, not "calculus was invented in Kerala."

An equally important honesty concerns transmission. Some scholars have hypothesized that Kerala results reached Europe through Jesuit missionaries active on the Malabar coast from the sixteenth century, possibly influencing later European developments (Joseph, 2011) [10]. The hypothesis is not absurd-the missionaries were there, and some

collected texts-but no documentary evidence of transmission of the mathematical content has been found, and mainstream historians, including those most sympathetic to the Indian tradition, treat the claim as unproven speculation (Plofker, 2009) [15]. The European calculus of Newton and Leibniz is, on present evidence, an independent development. Teachers should say exactly this. Indeed, the episode is itself pedagogically valuable as a case study in historical epistemology: students can be asked what would count as evidence of transmission (manuscripts, citations, correspondence) and why its absence matters. The Kerala achievement needs no borrowed luster; the first European notice of it, C. M. Whish's 1834 paper to the Royal Asiatic Society on the "Hindu quadrature of the circle," already recognized its stature (Whish, 1834) [23], and a century and a half of subsequent scholarship-from K. V. Sarma's editions to the annotated translations of the Yuktibhāṣā and Tantrasaṅgraha (Sarma, 2008; Ramasubramanian & Sriram, 2011) [19, 17]-has only confirmed it.

6. A Pedagogical Framework and Curriculum-Aligned Modules

Why should the history sketched above enter the mathematics classroom at all, rather than remain in history electives? Two research literatures supply the warrant. The first is ethnomathematics. D'Ambrosio (1985) [3] argued that mathematics as taught is the codified practice of particular cultural groups, and that recognizing the mathematical practices of learners' own cultures both restores historical truth and repairs the alienation of students who experience mathematics as foreign. Bishop (1988) [2] analyzed mathematics education as "mathematical enculturation," a values-laden induction into a way of knowing-counting, locating, measuring, designing, playing, explaining-that every culture elaborates. For Indian students, the Indian mathematical tradition is not exotic enrichment; it is the local instantiation of these universal activities, and its absence from the curriculum is itself a curricular decision with affective costs. The second literature concerns the use of history in mathematics education generally: Fauvel (1991) [7] and Jankvist (2009) [9] distinguish history as a tool (motivation, cognitive support, humanizing the subject) from history as a goal (understanding mathematics as a developing human enterprise), and both purposes are served by the Indian material. NCF-SE 2023 provides the policy hook: it explicitly directs that the school curriculum be rooted in the Indian context, that IKS be integrated within subjects rather than ghettoized, and that mathematics teaching move from procedure toward understanding, exploration, and appreciation of mathematics as a human endeavor (National Council of Educational Research and Training [NCERT], 2023). At the tertiary level, the University Grants Commission's framework for IKS credit courses creates space for a full elective on Indian mathematics (University Grants Commission, 2022) [22].

Against this background, four modules are proposed, each anchored in a specific curricular location, each using primary material in translation, and each carrying an explicit historical-integrity note for the teacher.

Module 1: Śulba geometry for the middle school (Grades 6-8).

Content: rope-and-peg construction of perpendiculars via the (3, 4, 5) and (5, 12, 13) triples; statement and empirical verification of the diagonal rule (Baudhāyana-śulbasūtra 1.12); transformation of a rectangle into a square of equal area; doubling the square via the diagonal and measuring the resulting approximation to $\sqrt{2}$ against the Baudhāyana value 577/408. Pedagogy: outdoor, collaborative construction followed by classroom formalization, exactly reversing the usual order of definition-first geometry and consistent with NCF-SE 2023's emphasis on concrete-to-abstract progression. Integrity note: teachers state that the śulbasūtras give rules and constructions, not Euclidean proofs; that Babylonian mathematics knew Pythagorean triples earlier; and that the Indian texts' distinctive features are generality of statement, constructive method, and the saviśeṣa awareness of approximation.

Module 2: The story of our numerals (Grades 6-9, and teacher education).

Content: comparative computation in Roman, Babylonian, and decimal place-value numeration; Brahmagupta's rules for zero and negatives read aloud in translation (Brāhmasphuṭasiddhānta 18.30-35) and compared with the students' own textbook rules; the transmission chain to al-Khwārizmī and Europe; the words "algorithm," "algebra," "sine" as fossils of transmission. Pedagogy: historical role-play and source comparison; an assessment task in which students explain to a younger child why "the zero" was a difficult idea. Integrity note: the placeholder-versus-number distinction; the debated dating of the Bakhshālī manuscript presented as an open scholarly question (Hayashi, 1995; Plofker *et al*., 2017) [8, 16] modeling for students how scholarship handles uncertainty.

Module 3: Kuṭṭaka and the Līlāvatī (secondary school enrichment and undergraduate number theory).

Content: linear indeterminate problems from astronomy; the kuṭṭaka algorithm worked in parallel with the extended Euclidean algorithm to exhibit their equivalence (Āryabhaṭīya, Gaṇitapāda 32-33; Keller, 2006) [12]; selected Līlāvatī problem-poems (the lotus offering, the bamboo broken by the wind-a diagonal-rule problem, the peacock and the snake) used as the word-problem bank for linear equations and quadratic applications. Extension for undergraduates: bhāvanā and cakravāla for $x^2 - Ny^2 = 1$, culminating in Bhāskara II's celebrated solution for N = 61 (Datta & Singh, 1935/1962; Plofker, 2009) [5, 15]. Pedagogy: students compose their own problem-poems in the Līlāvatī style in any Indian language, an activity uniting mathematics, language, and creativity in the multidisciplinary spirit of NEP 2020. Integrity note: attribution discipline-kuṭṭaka to Āryabhaṭa as transmitted and elaborated by Bhāskara I; cakravāla to Jayadeva and Bhāskara II.

Module 4: Kerala series as motivation for calculus (Grades 11-12 and first-year undergraduate). Content: numerical exploration of $\pi/4 = 1 - 1/3 + 1/5 - \cdots$ on a spreadsheet; observation of slow convergence; application of Mādhava's end-correction and comparison of accuracy-an authentic historical instance of convergence acceleration; a guided reading of the Yuktibhāṣā derivation of the arc-series in modern paraphrase (Sarma, 2008) [19], in which students see summations of powers and a limiting subdivision doing the work that Riemann sums will do in their calculus course; the sine series graphed term by term against sin x. Pedagogy: the module is positioned immediately before the formal introduction of limits and

integrals, so that calculus arrives as the systematization of ideas students have already watched at work historically. Integrity note: the Katz (1995) [11] formulation-elements of calculus anticipated, general theory not constructed; transmission to Europe unproven; Whish (1834) [23] as the rediscovery moment.

At the tertiary level, these modules can be consolidated into a full IKS elective, "History of Indian Mathematics," structured chronologically from the śulbasūtras through the Kerala school and taught from Plofker (2009) [15] and Divakaran (2018) [6] with primary-source readings in translation (Sen & Bag, 1983; Shukla & Sarma, 1976; Keller, 2006; Sarma, 2008) [12, 20, 21, 19]. Such a course serves three constituencies at once: mathematics majors, for whom it doubles as an introduction to number theory, numerical analysis, and the foundations of calculus through historical cases; prospective teachers, for whom it supplies the content knowledge on which the school modules depend; and Sanskrit and history students, for whom it opens technical śāstra literature otherwise inaccessible. Interdisciplinary team-teaching-mathematician and Sanskritist together-is the natural format and is explicitly encouraged by NEP 2020's push toward multidisciplinary institutions (MHRD, 2020).

Assessment across modules should reward historical reasoning as well as computation: source-based questions ("What exactly does Baudhāyana claim, and what does he not claim?"), error analysis, and reflective writing. For teacher preparation, the four-year Integrated Teacher Education Programme and in-service frameworks should include a foundational course in the history of Indian mathematics taught from mainstream scholarship (Plofker, 2009; Divakaran, 2018) [15, 6], since the modules fail-or worse, drift into myth-if teachers cannot themselves distinguish evidence from embellishment.

7. Cautions: "Vedic Mathematics," Overclaiming, and Institutional Risks

An article advocating IKS integration in mathematics must confront, directly, the phenomenon most likely to discredit it. The system publicized as "Vedic Mathematics," based on the posthumously published book of that title by Jagadguru Swami Bharati Krishna Tirtha (1965) [1], presents sixteen Sanskrit sūtras with arithmetic shortcuts (for instance, ūrdhva-tiryagbhyām cross-multiplication) claimed to derive from an appendix (pariśiṣṭa) of the Atharvaveda. The scholarly verdict, stated most influentially by the mathematician S. G. Dani, is unambiguous: the sūtras are found in no known Vedic text or pariśiṣṭa; their language is not Vedic Sanskrit; the tricks presuppose decimal place-value notation of the classical, not Vedic, period; and the corpus is best understood as an ingenious twentieth-century compilation of calculational shortcuts wrongly wrapped in Vedic authority (Dani, 1993) [4]. The book has genuine, modest uses-some of its shortcuts are pleasant mental-arithmetic exercises-but presenting it as ancient Indian mathematics commits three errors at once: it misattributes, it displaces the authentic tradition (a student drilled in "Vedic" multiplication tricks typically never hears of the kuṭṭaka or the Yuktibhāṣā), and it teaches students that cultural pride licenses indifference to evidence. Curriculum designers under NEP 2020 should therefore draw a bright line: the historical tradition documented by Datta and Singh, Sarasvati Amma, Sarma, and Plofker belongs in the mathematics classroom; Bharati Krishna Tirtha's system, if taught at all, belongs in a mental-arithmetic enrichment slot under its true twentieth-century description.

The same discipline applies to overclaiming at large. Assertions that the Vedas contain modern physics, that ancient India possessed calculus in full, or that all mathematics originates in India are not merely false; they are strategically self-defeating, because each exposed exaggeration taxes the credibility of the genuine record-and the genuine record, as this article has argued, is extraordinary enough. The policy language of NEP 2020 itself demands integration "in an accurate and scientific manner" (MHRD, 2020, para. 4.27); accuracy is thus not an external constraint on the policy but its internal standard. Three institutional safeguards follow. First, textbook and module development should be jointly vetted by historians of mathematics and mathematics educators, with primary-source citations required for every historical claim-an editorial norm that would have filtered out most existing popular errors. Second, teacher-education materials should explicitly train the distinction between attested text, commentarial elaboration, and modern reconstruction, using the $\sqrt{2}$ rule and the Mādhava attributions as worked examples of each category. Third, assessment frameworks should avoid incentivizing rote nationalist recitation ("Who invented zero?") in favor of source-grounded understanding ("What rule does Brahmagupta state for the product of two negatives, and what problem does he leave unresolved?").

There are also practical risks to manage: curricular time is finite, and history must serve, not crowd out, mathematical proficiency-hence the design choice above of embedding historical material inside existing syllabus topics rather than adding parallel content; and the multireligious classroom requires that ritual-origin material (the altar geometry) be taught as cultural and intellectual history, in the same register in which Egyptian surveying or Babylonian astronomy is taught, accessible to every student.

8. Conclusion

The Indian mathematical tradition offers the contemporary classroom something rarer than national pride: a continuous, documented, fifteen-hundred-year (indeed longer) record of mathematics being done-constructed on the ground with cords, compressed into memorable verse, justified in prose commentaries, pushed to the edge of the infinite-by identifiable people solving identifiable problems. The śulbasūtras model mathematics as embodied construction and honest approximation; Āryabhaṭa, Brahmagupta, and Bhāskara II model it as algorithm, algebra, and pedagogical art; the Kerala school models it as sustained theoretical imagination joined to explicit demonstration. Each stratum maps naturally onto a stage of the modern curriculum-middle-school geometry, secondary algebra and number theory, introductory calculus-and each can be taught from translated primary sources vetted by mainstream scholarship.

NEP 2020 and NCF-SE 2023 have created the policy space for this integration; whether the space is filled with scholarship or with slogans is the choice now before textbook writers, teacher educators, and university IKS programs. This article has argued that the choice is not between pride and rigor. The unembellished record-Baudhāyana's diagonal rule and saviśeṣa $\sqrt{2}$, Brahmagupta's arithmetic of zero and negatives, the kuṭṭaka and cakravāla, the Līlāvatī's problem-poems, Mādhava's series and the Yuktibhāṣā's rationales-is itself the strongest possible ground for pride, precisely because it needs no exaggeration

and survives every scrutiny. Conversely, every overclaim, every "Vedic Mathematics" conflation, every unproven transmission thesis stated as fact, spends down the credibility on which the whole enterprise depends. The pedagogical program proposed here-four curriculum-embedded modules, historian-vetted materials, teacher preparation in the history of mathematics, and assessment that rewards source-grounded reasoning-is offered as one concrete way to honor both the letter of the policy and the spirit of the tradition it invokes: a tradition whose own highest term of praise, after all, was yukti-reasoned justification. Future work should include empirical studies of these modules' effects on achievement and attitude, critical editions and accessible translations of more of the commentarial literature, and sustained collaboration between India's mathematics-education community and its historians of science. The mathematicians of the Nila valley wrote their rationales in Malayalam prose so that reasons, not merely rules, would be transmitted. Indian mathematics education under NEP 2020 could adopt no better motto.

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