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Integration of Indian Knowledge Systems in Mathematics Education: A Critical Analysis of NEP 2020

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Abstract:
The National Education Policy (NEP) 2020 proposes the systematic inclusion of Indian Knowledge Systems (IKS), including tribal, indigenous, classical, and local traditions, across school and higher education. Mathematics is specifically identified as an area in which such knowledge should be incorporated. This paper critically analyses the educational value, policy logic, and implementation challenges of integrating IKS into mathematics education. Drawing on NEP 2020, the National Curriculum Framework for School Education 2023, University Grants Commission guidelines, histories of Indian mathematics, and research on ethnomathematics and culturally sustaining pedagogy, the paper argues that IKS can make mathematics historically accurate, culturally meaningful, multilingual, and inquiry-oriented. Relevant examples include Indian place-value numeration, the algorithms of Aryabhata and Brahmagupta, geometric reasoning in the Śulbasūtras, regional games, crafts, architecture, measurement practices, and community knowledge. However, integration also risks tokenism, romanticisation, unsupported scientific claims, cultural homogenisation, curricular overload, and weakened disciplinary rigour. Effective implementation therefore requires source verification, mathematical reconstruction, comparative analysis, inclusive representation, teacher preparation, and evidence-based assessment. IKS should function as a bridge to rigorous mathematical thinking, not as a substitute for proof, contemporary knowledge, or universal standards of validation.

Keywords: Indian Knowledge Systems, mathematics education, NEP 2020, ethnomathematics, culturally responsive pedagogy.

Introduction

Mathematics is often presented as culturally neutral: a universal body of facts, procedures, and proofs detached from the societies in which mathematical ideas emerged. Although mathematical validity does not depend on nationality or culture, the questions people ask, the representations they use, and the methods through which they teach and apply mathematics are historically and culturally situated (Bishop, 1988; D'Ambrosio, 1985). The classroom can therefore communicate two messages simultaneously: mathematics has universal standards of reasoning, but mathematical knowledge has been produced by many communities.

India possesses a long and diverse mathematical heritage. Contributions associated with the decimal place-value system, zero, combinatorics, algebra, trigonometry, astronomy, geometry, and indeterminate equations arose within different linguistic, religious, occupational, and regional settings (Joseph, 2011; Plofker, 2009). Yet school mathematics frequently mentions this history only through isolated names or celebratory sidebars. NEP 2020 attempts to change this by calling for Indian knowledge to be integrated across subjects in an "accurate and scientific manner," explicitly including mathematics and indigenous and tribal ways of learning (Ministry of Human Resource Development [MHRD], 2020).

This paper asks whether such integration can improve mathematics education and under what conditions. It argues that IKS can enrich curriculum, pedagogy, and mathematical identity, but only when integration is plural, critical, evidence-based, and connected to clearly stated mathematical learning outcomes.

Analytical Framework and Scope

This paper uses critical policy analysis to examine policy intentions, pedagogical possibilities, and implementation risks. IKS is interpreted broadly to include classical mathematics, vernacular and tribal traditions, occupational practices, games, crafts, architecture, measurement, navigation, and accounting.

Ethnomathematics studies mathematical practices developed within cultural and social groups (D'Ambrosio, 1985). Communities may use classification, counting, estimation, measurement, spatial organisation, pattern creation, optimisation, and logic without conventional textbook notation.

However, an ethnomathematical example is educationally valuable only when learners identify, explain, represent, compare, and generalise the mathematics involved. A decorative pattern is not automatically a mathematics lesson. It becomes one when students analyse symmetry, transformation, ratio, tessellation, combinatorics, or another relevant concept. This distinction between cultural display and mathematical inquiry is central to a responsible interpretation of IKS.

NEP 2020 and the Policy Architecture for IKS

NEP 2020 presents rootedness in India's diverse cultural and intellectual traditions as a principle of educational reform. Paragraph 4.27 proposes that knowledge from ancient and modern India should enter the school curriculum wherever relevant and should be treated accurately and scientifically. It explicitly identifies mathematics, astronomy, philosophy, architecture, medicine, agriculture, engineering, linguistics, games, governance, and conservation as possible domains of integration (MHRD, 2020). The wording is important because it combines cultural recovery with standards of accuracy rather than granting traditional claims exemption from investigation.

The National Curriculum Framework for School Education 2023 extends this vision through experiential learning, multilingualism, local context, interdisciplinarity, and engagement with Indian knowledge and practices (National Council of Educational Research and Training [NCERT], 2023). It defines mathematics as a way of understanding the world through patterns, quantities, and measurement while emphasising problem-solving and logical reasoning. IKS materials can support this vision when they are integrated into mathematical inquiry rather than added as disconnected historical information.

At the higher-education level, the University Grants Commission (UGC, 2023) recommends that undergraduate and postgraduate students take IKS courses amounting to at least 5% of their mandated credits. It further recommends that part of the coursework be connected to the learner's major discipline.

For mathematics students, this creates space for historically grounded courses on Indian numeration, algebra, combinatorics, geometry, logic, astronomy, and computational traditions.

These policies provide institutional permission but not educational quality by themselves. Curriculum designers must translate cultural aims into grade-appropriate objectives, materials, assessments, and teacher competencies. The central challenge is how IKS can be transformed into rigorous learning.

Educational Potential of IKS Integration

Historical Accuracy and Epistemic Inclusion

A carefully designed IKS curriculum can correct the impression that significant mathematics travelled through a single Greek-to-European line of development. Indian mathematicians developed sophisticated algorithms and concepts within astronomy, prosody, commerce, ritual geometry, and other fields. Studying these contributions gives learners a more accurate history of mathematics and demonstrates that mathematical creativity has emerged from multiple intellectual centres (Joseph, 2011; Plofker, 2009).

Students may examine decimal place value, Brahmagupta’s rules for signed numbers, Aryabhata’s indeterminate equations, Pingala’s combinatorics, and Bhaskara II’s cyclic procedures, connecting concepts with the problems that produced them.

Historical inclusion can also strengthen mathematical identity. Students who encounter familiar names, languages, artefacts, and local practices may see mathematics as connected to their intellectual inheritance rather than as an imported collection of rules. Culturally sustaining mathematics education similarly seeks to affirm learners’ identities while preserving access to powerful disciplinary knowledge (Marshall, 2023). Nevertheless, identity-building should arise from defensible scholarship, not exaggerated claims that every modern scientific discovery was already known in ancient India.

Contextualisation and Conceptual Understanding

IKS can connect abstract mathematical ideas to meaningful contexts. Symmetry and transformation may be explored through rangoli, kolam, weaving, embroidery, temple designs, or architectural patterns. Measurement and proportional reasoning can be investigated through craft production, agricultural layouts, traditional units, construction techniques, or water-management structures. Probability and strategic thinking can emerge from regional games, while patterns in poetic metres can introduce binary representation and combinatorial reasoning.

Such tasks can move learning beyond memorisation. Students may reconstruct procedures, test examples, identify patterns, formulate conjectures, and compare representations. A kolam activity, for example, could examine reflectional and rotational symmetry, coordinates, area, and constrained pattern design.

Systematic reviews and meta-analyses of ethnomathematics-based learning report positive effects on student engagement, mathematical ability, and mathematical literacy (Hendriyanto et al., 2023; Pratama & Yelken, 2024). However, the evidence is context-dependent, and many studies involve relatively small samples or short interventions. Existing research therefore supports carefully designed experimentation rather than the assumption that every culturally themed lesson will automatically improve achievement.

Multiple Methods and Mathematical Reasoning

Historical Indian mathematics enables comparison between contemporary algorithms and earlier methods for multiplication, roots, indeterminate equations, counting, and construction. Older rhetorical procedures should not replace modern notation; rather, comparison can reveal place value, recursion, approximation, divisibility, and equivalence.

For example, an activity on Brahmagupta's algebra may ask students to translate a verbal rule into modern notation, test it with numerical examples, identify its domain of validity, and explain why it works. A lesson on geometric constructions associated with the Śulbasūtras could distinguish exact constructions from numerical approximations and compare practical procedures with formal proof.

This method also prevents the history of mathematics from becoming passive memorisation. Students do not merely learn that a mathematician developed a procedure; they reconstruct, test, and evaluate the procedure. Heritage is consequently transformed into mathematical analysis.

Multilingual and Community-Based Learning

NEP 2020's support for Indian languages can connect informal quantitative knowledge with formal vocabulary. Local terms for shape, quantity, estimation, sequence, and measurement may reduce linguistic barriers and help students explain reasoning confidently.

Community members, artisans, farmers, builders, traders, navigators, or weavers may also contribute authentic problems and practices. A weaving activity, for example, may reveal ratio, repeating patterns, transformation, and counting principles. Agricultural practices may demonstrate area calculation, estimation, optimisation, or proportional allocation.

However, multilingual teaching should lead to greater access rather than confinement. Students need carefully designed bridges among home-language explanations, standard mathematical terminology, symbolic notation, and, where necessary, English-language academic resources. IKS-based learning is strongest when it expands a learner's mathematical repertoire rather than restricting the learner to a local context.

Critical Concerns and Limitations

Romanticisation and the Problem of Evidence

The greatest danger is the replacement of historical neglect with uncritical glorification. Traditional texts may contain powerful mathematics, useful approximations, metaphysical ideas, empirical observations, and claims that do not satisfy modern standards of evidence. These categories must not be blurred.

Historical attribution should rely on manuscripts, inscriptions, translations, and scholarship. Teachers must distinguish documented methods, modern reconstructions, and later claims; otherwise, students may receive an attractive but inaccurate history.

The phrase "accurate and scientific manner" in NEP 2020 should therefore function as a methodological safeguard. Mathematical claims must be demonstrable through calculation, logical reasoning, or proof, while historical claims must be supported by credible evidence. Cultural respect does not require treating every inherited assertion as mathematically or scientifically valid.

Homogenising Indian Knowledge

India does not possess a single, uniform knowledge tradition. If IKS is reduced to a narrow canon of Sanskrit works or symbols associated with dominant communities, the policy may marginalise the diversity it claims to recognise. Tribal knowledge, vernacular mathematical texts, Buddhist and Jain traditions, Islamic-era scholarship in India, regional practices, women's knowledge, artisan expertise, and the mathematics of occupational communities require meaningful representation.

Curriculum selection therefore raises questions of power. Who decides which traditions qualify as knowledge? Who receives recognition as an author or mathematical thinker? Who is represented only as an anonymous cultural object? An inclusive curriculum should identify knowledge holders where possible, acknowledge disputed interpretations, and avoid representing living communities as unchanged remnants of an ancient past.

The term "Indian" should consequently refer to a plural and evolving intellectual space rather than a homogeneous civilisational identity.

Tokenism and Curricular Overload

Superficial integration may add portraits, quotations, festival examples, or "Did you know?" boxes without changing students' mathematical understanding. Such symbolic inclusion can consume classroom time while leaving both history and mathematics underdeveloped. Conversely, attempting to include too many traditions may overload an already demanding curriculum.

Every IKS activity should answer three questions. First, what mathematical concept is being learned? Second, what evidence supports the cultural or historical account? Third, what will students be able to reason, calculate, model, represent, or prove after completing the activity?

If these questions cannot be answered, the material may be appropriate for cultural or historical studies but not necessarily for a mathematics lesson. Integration should deepen the existing curriculum rather than operate as an unrelated additional syllabus.

Teacher Capacity and Resource Quality

Many mathematics teachers lack preparation in history, source criticism, multilingual pedagogy, and culturally sensitive curriculum design. They may repeat myths, oversimplify procedures, or misrepresent communities, while reliable translations and local resources remain unevenly available.

Teacher education must therefore include subject knowledge, pedagogical content knowledge, and basic historical method. Teachers need curated primary-source excerpts, scholarly annotations, worked mathematical reconstructions, classroom tasks, and warnings about frequent misattributions. Short-term workshops alone are unlikely to provide the necessary expertise.

Collaboration among mathematicians, historians, mathematics educators, linguists, archaeologists, and community knowledge holders is essential. Such collaboration can ensure that materials are historically responsible, mathematically rigorous, pedagogically appropriate, and culturally respectful.

Assessment and Empirical Evaluation

IKS integration can become performative when institutions count the number of courses, textbook references, or cultural activities without examining what students have learned. Assessment should measure mathematical reasoning and critical understanding rather than patriotic recall.

Students might reconstruct an algorithm, prove an identity, model a community practice, evaluate an approximation, compare historical and modern procedures, or assess the evidence supporting a historical claim. Project-based assessment may be particularly appropriate where students document local practices and translate them into mathematical representations.

Implementation also requires systematic research. Pilot programmes should compare student achievement, engagement, mathematical identity, inclusion, teacher workload, and the transfer of learning across different regions and school types. Existing ethnomathematics research is promising, but it does not yet justify universal claims across every mathematical topic and student population (Hendriyanto et al., 2023; Pratama & Yelken, 2024).

A Framework for Responsible Integration

A responsible integration model should have five features. First, curriculum development should begin with mathematical learning outcomes, followed by the selection of an authentic IKS context that genuinely illuminates those outcomes. Cultural content should not be selected first and then forced into an unrelated mathematical chapter.

Second, each teaching module should include source information and clearly distinguish historical evidence from interpretation. Claims of invention, priority, or scientific achievement should undergo expert review.

Third, learning should progress through three stages: cultural context, mathematical abstraction, and renewed application. Students may begin with a local design or historical algorithm, identify its mathematical structure, express that structure using standard notation, and then apply it to a new problem.

Fourth, IKS modules should be plural and locally adaptable. A national curriculum may provide common principles and verified examples, but states, schools, and communities should be able to include regionally meaningful practices. Local adaptation should nevertheless preserve national learning standards.

Fifth, evaluation should examine both disciplinary learning and cultural understanding. Students should demonstrate that they understand the mathematics while also recognising the historical, social, or occupational context in which the knowledge developed.

At the school level, short inquiry modules can be embedded within existing units. A geometry unit may analyse transformations in local designs; a number unit may compare place-value representations; an algebra unit may reconstruct an Indian algorithm; and a statistics unit may investigate local environmental or occupational data.

At the university level, mathematics-history courses can combine textual study with formal mathematical reconstruction. Teacher-education programmes can require candidates to design, teach, and evaluate an IKS-based mathematics lesson. Courses should also address misinformation, contested historical claims, and the ethics of documenting community knowledge.

A national, peer-reviewed digital repository could support quality and equity. Resources should state provenance, translation, mathematical explanation, grade level, outcomes, and assessment tasks, and should be available in multiple Indian languages. Community contributors should be acknowledged and compensated.

Conclusion

NEP 2020 creates an important opportunity to make mathematics education more historically truthful, culturally responsive, and intellectually plural. Indian mathematical traditions and living community practices can enrich lessons on number, algebra, geometry, combinatorics, measurement, patterns, and problem-solving. They can also challenge the false opposition between universal mathematics and culturally situated mathematical activity.

However, integration is not automatically progressive. Without historical verification, plural representation, trained teachers, and clearly defined mathematical outcomes, IKS may result in tokenism, mythology, exclusion, or curricular distraction. The appropriate aim is neither to reject traditional knowledge as inherently unscientific nor to celebrate it without examination. It is to place Indian knowledge in a disciplined conversation with contemporary mathematics.

The success of NEP 2020 should therefore be judged not by the number of heritage references added to textbooks, but by whether students reason more deeply, understand mathematics more broadly, evaluate evidence more carefully, and recognise themselves and others as participants in mathematical knowledge-making.

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