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INTEGRATING INDIGENOUS MATHEMATICAL KNOWLEDGE INTO CONTEMPORARY EDUCATION: RELEVANCE, PEDAGOGICAL IMPLICATIONS, AND SUSTAINABLE PERSPECTIVES

Chaitali Ghosh[1], Trisha Banerjee [2]

[1,2]*Research Scholar, Department of Teacher Education, Central University of South Bihar, Gaya Ji*
[1]*https://orcid.org/0009-0002-5755-6344*
[2]*https://orcid.org/0009-0006-3035-4629*

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ABSTRACT

Indigenous Knowledge (IK) refers to the accumulated wisdom, skills, and practices developed by communities over generations through their interaction with the environment and cultural experiences. Indigenous Mathematical Knowledge (IMK), as a component of this broader system, represents the mathematical ideas and practices embedded in the cultural traditions, daily activities, and lived experiences of indigenous communities. It includes diverse approaches to counting, measuring, patterning, and problem-solving that are closely connected to local environments and socio-cultural contexts. Recognising the significance of such knowledge systems, there is a growing need to incorporate IMK into contemporary education to make mathematics more meaningful, inclusive, and accessible. This study is guided by two objectives: to analyse the relevance of Indigenous Mathematical Knowledge in contemporary education, and to explore the pedagogical implications and sustainable perspectives of integrating IMK in mathematics education. The study adopts a review-based methodology, drawing on research articles, literature on ethnomathematics and Indigenous Mathematical Knowledge, reports on Indigenous Knowledge Systems (IKS), and studies of indigenous practices. The findings of the study are organised around three key dimensions: the relevance of IMK in contemporary education, its pedagogical implications for teaching–learning processes, and its contribution to sustainable perspectives. These dimensions collectively highlight the potential of IMK to make mathematics education more inclusive, contextually meaningful, and aligned with sustainability goals. The analysis suggests that integrating IMK can strengthen students' engagement, connect mathematics with real-life experiences, and promote equity, particularly for indigenous and rural learners. Furthermore, it fosters ecological awareness, ethical values, and locally grounded problem-solving approaches. In alignment with frameworks such as the National Education Policy 2020 and SDG 4, the study concludes that recognizing IMK as a dynamic and evolving knowledge system can transform mathematics education into a more holistic, inclusive, and sustainable discipline, despite having challenges related to implementation and standardisation.

KEYWORDS*: Indigenous Mathematical Knowledge, Indigenous Knowledge System, Contemporary Education, Pedagogical Implications, Sustainable perspectives*

INTRODUCTION

India has a long tradition of rich indigenous and classical mathematical knowledge, ranging from tribal counting practices to advanced systems of mathematics. Recent work on Indian Knowledge Systems and ethnomathematics shows that integrating this knowledge into modern classrooms can support cultural identity, deepen conceptual understanding, and promote sustainability-oriented thinking (Tyagi, 2025; Sahu, 2025; Demssie et al., 2020; Sharma & Bakshi, 2025). Research on incorporating indigenous knowledge into mathematics education in other countries also provides valuable design insights that are relevant for the Indian context (Utami et al., 2021; Garcia-Olp et al., 2022; Chen & Wu, 2024). Mathematics is often perceived as a universal discipline, yet its origins and applications are deeply rooted in cultural practices. Indigenous communities across the world have developed diverse mathematical systems through everyday activities such as agriculture, architecture, navigation, and crafts. These systems, collectively referred to as Indigenous Mathematical Knowledge, reflect practical, context-specific, and experiential forms of mathematics. However, the contemporary education system largely emphasises abstract and standardised mathematical knowledge, often neglecting indigenous perspectives. Learners often struggle with many mathematical concepts and processes and feel disconnected from their lived and cultural experiences. This makes mathematics more abstract and difficult to understand. Ineffective teaching methods further increase this difficulty. As a result, learners develop low interest and confidence in the subject. Ultimately, this leads to poor understanding and academic performance.

This challenge can be minimised by connecting school mathematics with learners' everyday experiences through the use of indigenous mathematical knowledge (Mkhwelie et al., 2022). Therefore, integrating indigenous mathematical knowledge into formal mathematics education is proposed as an effective way to promote a better understanding of mathematical concepts and to make it more meaningful,

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inclusive, and sustainable. In this context, the present paper aims to examine the relevance of integrating Indigenous Mathematical Knowledge into contemporary Indian education, analyse its pedagogical implications, and explore its potential for promoting sustainable and culturally responsive learning practices.

THEORETICAL BACKGROUND OF INDIGENOUS MATHEMATICAL KNOWLEDGE

Indigenous knowledge refers to the understanding and practices developed by communities over generations, often in harmony with their natural environment. This knowledge includes ecological, agricultural, and medicinal insights (UNESCO, n.d). Indigenous knowledge is generally used anonymously with traditional and local knowledge to differentiate the knowledge developed by and within distinctive indigenous communities (Chahine, 2013). Indigenous Knowledge Systems have been recently established by the international world organisations as a top global priority for empowering traditional and local communities in their striving efforts towards improved and sustainable development, particularly in developing countries (Kapoor & Shizha, 2010). The current global paradigm shift towards promoting education for sustainable development gravitates toward the integration of indigenous knowledges into the contemporary education system. Indigenous Knowledge Systems significantly contribute to learners' cognitive development and play a crucial role in fostering effective and meaningful mathematics learning in both formal and informal contexts.

Indigenous knowledges and mathematical concepts are embodied in many indigenous activities, and much of the knowledge is mainly transmitted through oral narratives, ritual ceremonies, traditional songs, storytelling, riddles, proverbs and other cultural practices (D'Ambrosio, 2001). Mathematics is as old as humankind and is practiced by all indigenous communities in their different settings as part of their everyday life (Orey & Rosa, 2008). For example, there are many different counting systems that have been developed in the world. As an illustration, concepts such as symmetry, radius, area and perimeter are embedded in indigenous people's activities such as pottery designs, basket weaving, and artwork. A good example of mathematics in everyday life is when people at home apply the concept of ratio and proportion during the preparation of food. Thus. Indigenous Mathematical Knowledge refers to the distinct mathematical concepts, systems, and practices developed by Indigenous communities to navigate their surroundings. Ethnomathematics is one of the components of Indigenous Knowledge Systems. D'Ambrosio (2001), the Brazilian mathematician who coined the term ethnomathematics, is regarded as the father of ethnomathematics. He broadly describes ethnomathematics as the form of mathematics that emerges from and is practiced within distinct cultural groups in society (Powell & Frankenstein, 1997). Thus, D'Ambrosio did not restrict the term to mean only ethnic groups or groups of people in a certain geographical area, but encompassed different groups in a society. On the other hand, Constructivist theory suggests that learners actively construct knowledge through experiences. IMK aligns with this approach by providing experiential and context-based learning opportunities rooted in real-life situations (Mkhwelie et al., 2022).

OBJECTIVES OF THE STUDY

1. To analyse the relevance of Indigenous Mathematical Knowledge in contemporary education.
2. To explore the pedagogical implications and sustainable perspectives of integrating Indigenous Mathematical Knowledge in mathematics education.

METHODOLOGY

This study adopts a review-based approach. Data has been collected from research articles and literature on Indigenous Mathematical Knowledge and Ethnomathematics, reports on Indigenous Knowledge Systems, and studies of indigenous practices. The analysis focuses on relevance, pedagogy and sustainability of Indigenous Mathematical Knowledge in teaching -learning.

RELEVANCE OF INDIGENOUS MATHEMATICAL KNOWLEDGE IN CONTEMPORARY EDUCATION

Indigenous Mathematical Knowledge is highly relevant as it connects abstract mathematical concepts with real-life contexts. It enhances learners' understanding by grounding mathematics in familiar experiences such as counting, measuring, and pattern recognition. Additionally, IMK promotes inclusivity by recognising diverse cultural knowledge systems. Thus, bridging traditional and modern knowledge, IMK contributes to a more holistic, multidimensional and meaningful approach to contemporary education. The relevance of Indigenous Mathematical Knowledge in contemporary education can be understood through multiple dimensions:

i) Contextual and Cultural Relevance

One of the most significant contributions of Indigenous Mathematical Knowledge is its ability to make mathematics culturally meaningful and contextually grounded. Indigenous communities possess rich and diverse mathematical practices, including unique measurement systems, counting systems, and distinctive patterns. For instance, indigenous measurement systems often rely on body parts or natural elements, while counting systems may vary in structure and base, reflecting cultural specificity. For example, before the metric system, Indian societies, including the Munda and Ho, employed anthropometric units derived from the human body and local objects. These were: Anguli (width of a finger), Haath (from elbow to tip of finger, approximately 18 inches), Gaz (yard, but locally variable-36 inches in Bengal, 27 in Bombay, 33 in Madras) and Bigha (area of land, regionally variable) (Priya et al., 2025).

Activities such as basket weaving, traditional architecture, and agricultural practices demonstrate the application of concepts like counting, symmetry, patterns, spatial reasoning, and measurement. Similarly, tribal art and craft traditions exhibit intricate geometric patterns and designs that embody mathematical thinking. Thus, culturally relevant and contextual learning rooted in indigenous communities can significantly enrich traditional classroom practices, leading to improved understanding of mathematical concepts. By integrating learners' cultural backgrounds into instruction, mathematics

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becomes less abstract, more engaging, and more meaningful, thereby enhancing comprehension, participation, and overall learning outcomes.

ii) Enhancing Conceptual Understanding

Indigenous Mathematical Knowledge strengthens conceptual understanding by connecting abstract mathematical ideas with concrete, real-life experiences. It is manifested in various cultural artifacts and everyday practices. Activities like traditional construction illustrate geometry and spatial reasoning, while agricultural practices involve measurement and estimation. Similarly, crafts and sewing practices reflect mathematical ideas such as patterns, symmetry, and geometric transformations. A study of the Damara community in southwestern Namibia shows that traditional practices like sewing and house construction incorporate mathematical concepts such as symmetry, trigonometry, and the Pythagorean Theorem (Sullivan & Ganuses, 2020). Their embroidery also reflects geometric transformations like reflection and rotation. Similarly, Anggraeni et al. (2018) found that Indigenous batik patterns of Indonesia contain some geometric transformation concepts, namely translation, rotation, reflection and dilation (Mkhwelie et al., 2022). By translating these indigenous activities into classroom tasks, learners gain better conceptual clarity and enhanced problem-solving skills, making mathematics more meaningful and relatable. This approach shifts learning from rote memorization to experiential understanding.

In addition, integrating IMK into mathematics education can significantly enhance the curriculum by offering learners a wider and clearer understanding of mathematical ideas. Practices such as traditional counting systems, measurement techniques, and problem-solving methods present diverse approaches that deepen students' grasp of mathematical concepts. and also help educators to make learning more relatable, engaging, and meaningful (Kadonsi, 2024).

iii) Promoting Learner Engagement and Motivation

Mathematics is frequently viewed by students as abstract, challenging, and unrelated to their daily experiences, which often results in anxiety, low motivation, and limited participation (Bishop, 1989; D'Ambrosio, 2001). Such perceptions are further reinforced by traditional teaching methods that rely heavily on rote memorization and context-free problem-solving. Additionally, dominant Western pedagogical approaches often fail to reflect learners' cultural contexts and lived realities, contributing to disengagement and weaker performance in mathematics (Gay, 2010). The integration of Indigenous Mathematical Knowledge offers a meaningful way to overcome these challenges by presenting mathematical concepts within familiar cultural settings. When learners encounter mathematics through everyday practices—such as crafts, farming activities, building techniques, and traditional games—they are more likely to perceive it as relevant and engaging (Gerdes, 1998; Zaslavsky, 1999). This culturally grounded approach not only increases interest and participation but also builds confidence and supports a deeper understanding of mathematical concepts.

Furthermore, culturally responsive teaching through IMK fosters a sense of identity and belonging by valuing learners' cultural knowledge. This enhances motivation, encourages active engagement, and supports deeper understanding, ultimately improving mathematical learning outcomes.

iv) Supporting Inclusive and Equitable Education

Integrating Indigenous Mathematical Knowledge supports inclusive and equitable education by recognizing and valuing diverse knowledge systems. It advances epistemic justice by challenging the dominance of Western approaches in mathematics education and legitimizing indigenous ways of thinking, learning, and problem-solving. In this regard, ethnomathematics serves as a significant tool for decolonizing education, encouraging the revision of curricula to include the knowledge and contributions of marginalized and indigenous communities that have historically been overlooked.

By incorporating these perspectives, education becomes more reflective of cultural diversity and responsive to the needs of all learners. This not only promotes inclusivity and respect for different cultural identities but also fosters a more balanced learning environment where multiple ways of understanding mathematics are acknowledged and appreciated.

v) Bridging School Knowledge and Community Knowledge

Indigenous Mathematical Knowledge plays a crucial role in linking formal school education with the lived experiences and practices of local communities, thereby making mathematics more meaningful and contextually relevant for learners. Instead of viewing mathematics as an abstract and isolated subject, IMK enables students to recognize its presence in everyday activities such as agriculture, trade, craftsmanship, architecture, and traditional games. This connection helps learners develop a deeper understanding of mathematical concepts by situating them within familiar cultural contexts.

Furthermore, IMK encourages active collaboration between schools and community members, including elders, artisans, and practitioners, who serve as valuable knowledge holders. Through such interactions, students gain exposure to indigenous methods of counting, measuring, pattern-making, and problem-solving, which often reflect sophisticated mathematical thinking. Research indicates that these school–community partnerships not only enhance students' engagement, conceptual clarity, and overall learning outcomes but also foster respect for cultural diversity and contribute to the preservation and transmission of indigenous knowledge systems across generations (Mkhwelie et al., 2022).

vi) Preservation of Indigenous Knowledge Systems

The preservation of Indigenous Knowledge Systems is vital for safeguarding cultural identity, sustaining traditional practices, and ensuring that valuable knowledge is passed down to future generations. Within mathematics education, Indigenous Mathematical Knowledge is deeply rooted in oral traditions, everyday activities, rituals, and community practices. However, due to factors such as modernization, globalization, and the dominance of Western-oriented education, much of this

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knowledge remains undocumented and is at risk of disappearing. Incorporating IMK into formal curricula not only helps in preserving these knowledge systems but also acknowledges their relevance and legitimacy in contemporary learning.

In Jharkhand, tribal communities such as the Santhal, Munda, Oraon, and Ho demonstrate rich mathematical understanding through their cultural practices and oral traditions. They employ indigenous counting methods in their local languages, use traditional measurement systems in farming and construction, and produce detailed geometric designs in art forms like Sohrai and Khovar paintings. Moreover, storytelling, songs, and folklore serve as important tools for conveying mathematical ideas such as patterns, sequences, and logical thinking. These examples highlight how mathematics is naturally integrated into daily life within these communities. Studies emphasise that documenting and integrating such indigenous practices into formal education can support cultural preservation while also enhancing the relevance and effectiveness of mathematics learning (Priya et. al., 2025).

vii) Contribution to Sustainable Development

Indigenous Mathematical Knowledge plays an important role in supporting sustainable development by encouraging practices that are ecologically sensitive, context-specific, and efficient in the use of resources. Indigenous communities have traditionally applied mathematical understanding in activities such as farming, water conservation, construction, and resource management, often guided by a deep awareness of natural cycles and environmental balance. Practices like land measurement, seasonal planning, and crop management demonstrate a strong connection between mathematics and sustainability. Incorporating these approaches into mathematics education not only enriches the curriculum but also nurtures environmental consciousness and critical thinking among learners, enabling them to apply mathematical knowledge to real-world sustainability challenges.

viii) Challenging the Eurocentric View of Mathematics

Integrating Indigenous Mathematical Knowledge into education helps question and move beyond the Eurocentric notion that mathematics is a neutral and universally developed discipline rooted mainly in Western traditions. In contrast, mathematical ideas have evolved within diverse cultural contexts, each offering distinct methods, systems, and ways of reasoning. Recognizing indigenous practices—such as local counting methods, spatial designs in crafts, and culturally grounded problem-solving techniques—makes mathematics education more inclusive and representative. This perspective challenges the dominance of Western knowledge systems and supports epistemic diversity by valuing multiple knowledge traditions. It also empowers learners, particularly those from indigenous communities, by validating their cultural heritage and enhancing their engagement and confidence in learning mathematics.

POLICY PERSPECTIVE: INSIGHTS FROM NATIONAL EDUCATION POLICY 2020

The National Education Policy 2020 (NEP 2020) provides a strong framework for integrating Indigenous Mathematical Knowledge into contemporary education by emphasising the inclusion of Indian Knowledge Systems to make learning more holistic, culturally rooted, and relevant. It promotes **contextual and experiential learning,** the incorporation of **local traditions into curricula,** and the value of **multilingualism and cultural diversity**, all of which support the transmission of indigenous knowledge. The policy also highlights the need to **bridge traditional and modern knowledge systems**, creating a more inclusive and balanced educational approach. Thus, NEP 2020 envisions education as connected to learners' socio-cultural contexts, aligning well with the integration of IMK to foster meaningful learning, critical thinking, creativity, and sustainability (Ministry of Human Resource Development, Government of India, 2020).

PEDAGOGICAL IMPLICATIONS OF INDIGENOUS MATHEMATICAL EDUCATION

Indigenous Mathematical Education is an approach that integrates local, cultural knowledge and traditional practices into mathematical teaching to make it more relevant for indigenous learners. Its pedagogical implications are equally important for both school and higher-education teachers, curriculum designers, and policymakers who wish to make mathematics more meaningful, inclusive, and sustainable.

i. Making Mathematics Learning Culturally Relevant and Meaningful

One central pedagogical implication is that teaching should deliberately connect mathematical ideas to learners' everyday environments and cultural practices. Indigenous mathematical knowledge provides concrete, context-rich examples of the learning contents. When students see that their community's ways of measuring land or sharing resources use the same mathematical logic as their school-based content, mathematics feels less foreign and more personally relevant to them. This requires teachers to move beyond textbook examples and instead design tasks that draw on local farming, craftwork, or local trade practices, so learners can "mathematize" their own lives. A mathematics teacher can use indigenous tools as teaching and learning materials (TLM) while designing their lesson plans and can systematically map them to their teaching units. As an example, a teacher can design units around Gond or Warli painting to teach coordinate grids, symmetry, scaling, and ratios. Research in rural schools shows that when teachers use local cultural practices and artifacts, learners better connect school mathematics with real-world situations and develop higher-order thinking (Gula & Jojo, 2024; Utami et al., 2021; Matindike & Ramdhany, 2024).

ii.Shifting from Transmission to Co-Constructive Pedagogy

The integration of Indigenous Mathematical Knowledge is a shift from a traditional transmission model to a more co-constructive classroom culture. Instead of the teacher as the sole source of correct knowledge, the classroom has become a space where students can live their experiences and have formal mathematical dialogue with one another. Teachers can invite students to bring in examples from home—such as how

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quantities are divided in food distribution, how plots of land are estimated, or how traditional games use spatial and numerical reasoning—then use these as the basis for guided discussions and problem-solving. This approach supports ethnomathematical and culturally responsive pedagogies, where the curriculum is not imposed from outside but collectively designed with local ways of knowing.

iii) Enriching Teaching Methods and Assessment Techniques

Indigenous Mathematical Education suggests that conventional drill-and-practice methods should be supplemented with project-based learning, inquiry-based tasks, and place-based activities anchored in IMK. For example, students can map their village, design patterns inspired by local textiles or pottery, or analyse traditional games that involve counting, probability, or strategy. These activities not only deepen conceptual understanding but also develop higher-order thinking and collaboration. Instead of concentrating just on standardised examinations, assessment techniques need to be changed. Teachers can assess students using portfolios, group projects, and oral explanations that demonstrate how they relate formal symbols to cultural practices. This aligns with the idea that mathematics is not just a set of procedures, but a social and historical practice of multiple valid expressions.

iv) Promote Inclusion and Equity in Mathematics Education

An important pedagogical implication is that integrating Indigenous knowledge with mathematics can strengthen inclusion and equity in mathematics education. Students from marginalised or indigenous communities often feel alienated because the curriculum ignores their backgrounds and languages. By valuing local counting systems, measurement terms, and oral traditions-based reasoning, teachers affirm students' identities and help them see that their knowledge is worthy of being inside the classroom. This builds confidence, increases engagement, and lowers the psychological barrier many students feel toward mathematics. Pedagogically, this means teacher-education courses must explicitly train teachers in cultural sensitivity, decolonial perspectives, and strategies for drawing on local knowledge without making communities feel weird. It will also help teachers to learn how to connect indigenous knowledge with formal curricula without oversimplifying or misrepresenting it (Gula & Jojo, 2024; Tyagi, 2025; Sahu, 2025).

APPLICATIONS OF INDIGENOUS MATHEMATICAL KNOWLEDGE FROM A PEDAGOGICAL PERSPECTIVE

In the Indian setting, integrating Indigenous mathematical knowledge into modern schooling takes on rich, tangible forms. The examples listed below demonstrate how educators can integrate formal mathematics with local practices in the classroom.

i. Everyday trade and measurement in markets

In most Indian towns and villages, vegetable vendors, milk sellers, and small shopkeepers use intuitive arithmetic—calculating weights, change, and discounts—often mentally or with simple tools like stones or coins. A teacher can design problems around typical market situations, estimating the cost of five vegetables bought in different quantities, or checking whether a given offer is actually beneficial for someone. This not only practises fractions, percentages, and mental arithmetic, but also validates students' home-based numeracy as legitimate mathematical knowledge.

ii. Traditional agricultural and land-related practices

Farmers in many regions estimate land area by steps, sticks, or ropes, and divide fields among family members. In states like Bihar, Jharkhand and Odisha, tribes such as Santhal, Munda, and Ho use estimation and counting while planting seeds, sharing land, and managing crop rotations. A classroom task can ask students to redraw their family's plot on grid paper, convert local units (like 'kathas' or 'bighas') into square metres, and find perimeters and areas, linking geometry to real-life agricultural planning.

iii. Weaving, Embroidery, and Craft Patterns

Tribal weaving patterns from Bhil, Santhal or Naga communities are used to explore symmetry, tessellations, fractions of designs and transformations (Utami et al., 2021; Garcia-Olp et al., 2022; Luecke, 2025). From saree borders in Banarasi and Chanderi weaves to Kolam or rangoli designs in Tamil Nadu and Kerala, the use of symmetry, repetition, and rhythmic patterns reflects the rich geometric ideas. Teachers can invite students to analyse such patterns, identify symmetry axes, translational or rotational symmetries, and then design their own motifs using transformational geometry.

iv. Traditional games and board-based reasoning:

Traditional games such as Pachisi (an ancient cross and circle board game whose modernised form is Ludo), Pallanguzhi (a board game in Tamil Nadu and Kerala played with seeds, shells and pebbles), or Gilli-Danda (an ancient South Asian outdoor game played with two wooden sticks) embed number relations, probability, and strategic thinking (Utami et al., 2021; Garcia-Olp et al., 2022; Luecke, 2025; Sharma & Bakshi, 2025; Hadebe-Ndlovu & Manditereza, 2025). Students can compute the likelihood of landing on a particular square, predict likely moves, or create their own game boards with specific numerical rules. This supports combinatorics and probability in a playful, culture-rooted setting that many children already know and enjoy.

v. Oral-tradition, counting, and sticks-based arithmetic:

Across India, diverse tribal communities possess unique counting systems that reflect their cultural practices, ecological interactions, and everyday needs. These systems often use body-based counting, local objects, or context-specific groupings to represent quantities, offering alternative ways of understanding numbers and numerical relationships. Santhal and Munda communities in eastern India traditionally use body-based counting systems, where fingers, joints, or other body parts serve as reference points for enumeration. Similarly, the Bhil and Gond communities have been observed to use object-based and grouping methods—such as counting in clusters of sticks, marbles, seeds, stones, or agricultural units—which reflect implicit understandings of aggregation, base structures, and early place value concepts. In some cases, counting is

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embedded in livelihood activities like farming, foraging, or trade, where quantities are estimated, grouped, and negotiated contextually rather than through formal numerals. Teachers can recreate this in class by using similar objects for addition, subtraction, and simple multiplication, helping weaker learners visualise numbers concretely. By engaging with these indigenous counting methods, learners can appreciate multiple representations of numbers and recognise mathematics as a culturally embedded and context-responsive form of knowledge rather than a purely abstract discipline. This mirrors the earlier Indian pathshala tradition, where oral recitation and recollective memory were central to building strong mental-arithmetic skills.

vi. Traditional calendars and ritual-related number work

Many rural and tribal communities follow seasonal calendars tied to agricultural cycles with time measurement and modular arithmetic, festivals, or rituals, often linked to lunar or solar observations (Tyagi, 2025; Sahu, 2025; Puri, 2025). Students can collect information about local festivals and their dates, then model them on a number line, explore periodicity, and discuss how different calendars (lunar vs solar) count days and months. This connects algebraic ideas of patterns and cycles to students' lived cultural experiences.

vii. Village-based spatial knowledge and navigation

In tribal and rural settings, people frequently use landmarks and spatial relations for travel and field work. For example, directions may be given with reference to a sacred tree, a pond, or a mountain, reflecting informal coordinate-like reasoning. Teachers can design tasks in which students create village maps using scale, direction words, and simple coordinates; thus, everyday navigation can be turned into formal geometry and measurement.

INTEGRATING INDIGENOUS MATHEMATICAL KNOWLEDGE WITH SUSTAINABLE EDUCATION

The integration of indigenous mathematical knowledge into contemporary education represents a transformative shift toward a more holistic, culturally relevant, and sustainable pedagogical framework. This approach aligns with the National Education Policy (NEP) 2020 and the United Nations' Sustainable Development Goal 4 (**SDG 4**), which emphasises inclusive and equitable quality education. By recognising mathematics not merely as an abstract set of rules but as a cultural and social phenomenon, educators can foster a deeper connection between learners and their environments, promoting long-term sustainability and ethical stewardship. Indigenous practices provide time-tested strategies for maintaining balance with nature, which are directly relevant to modern sustainability goals. Integrating these practices into mathematics helps students see this subject as a tool for survival and community well-being. The integration of IKS into the mathematics curriculum fosters several key sustainability competencies essential for the 21st-century learner, such as Systemic or Holistic Thinking and Critical Reflection, in which students learn to understand the complex interconnections between human and natural systems, moving beyond linear problem-solving. Indigenous mathematics activities, such as community-based resource management, encourage students to make decisions based on ethical responsibilities to future generations (Demssie et al., 2020; Chen & Wu, 2024; S & M, 2023), and thus they learn Collaboration and Value-Based Decision Making. It also helps in creating Ecological Awareness among the students.

Integrating with Sustainable Development Goals

The primary focus of IKS in education is to attain **Quality Education** (**SDG 4)**, but the sources highlight that indigenous mathematical practices directly contribute to a wide array of other sustainable goals, too. Mathematical modelling applied to sustainability themes encourages responsible behaviors regarding **water conservation** (**SDG 6** - Clean Water and Sanitation). Framing problems around traditional rainfall measurement and community water-sharing practices transforms mathematics into a functional language for environmental management. Through indigenous worldviews, educators address **social inequality** (**SDG 10** -Reduced Inequality) and the historical marginalization of tribal knowledge. Use of local languages and scripts in which mathematical expressions are embedded ensures that education is inclusive. Disaster-preparedness education utilises this traditional knowledge—such as coastal communities' understanding of tides or hill tribes' engineering of drainage systems—to build **community resilience** and safety (**SDG 11**-Sustainable Cities and Communities). The knowledge held by coastal tribal communities regarding tides and cyclones can inform school projects on data analysis and probability. Similarly, hill tribe practices of building terraces and drainage systems illustrate complex concepts of geometry, slope, and optimization. Indigenous mathematics often revolves around community-based **resource management**. Teaching students to model resource use and **analyse waste patterns** mathematically (**SDG 12**-Responsible Consumption and Production) will eventually help them to manage resources. IKS provides alternative perspectives for dealing with **climate change**. Integrating traditional observation of natural signs (wind patterns, river levels) into curricula helps students understand and act on **climate-related risks** (**SDG13**-climate action). Practices such as building terraces for soil conservation and managing forest use involve complex concepts of geometry and optimization while promoting **biodiversity** and the long-term stewardship of the land (**SDG 15**-life on land).

IMPLEMENTATION PATHWAYS TOWARDS A SUSTAINABLE, CULTURALLY GROUNDED MATHEMATICS CURRICULUM

Combining the results from the Indigenous Knowledge System, ethnomathematics, and sustainable education research, several design directions emerge for the Indian context:

i. **Start from worldviews, not only methods**: Sustainability-oriented education should begin by recognising indigenous worldviews and their holistic understanding of systems, then derive pedagogies that express these views, rather than simply inserting examples into existing textbooks (Demssie et al., 2020; Chen & Wu, 2024; S & M, 2023).

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ii. **Use local language and community participation**: Inviting elders and knowledge holders as guest contributors, using local terms for quantities and shapes, and documenting tribal practices in collaboration with communities can make the curriculum truly participatory and respectful (Gula & Jojo, 2024; Tyagi, 2025; Sahu, 2025; Demssie et al., 2020).

iii. **Blend local, classical, and global mathematics**: A balanced curriculum can connect tribal practices, ancient Indian mathematical texts, and modern formal mathematics, showing multiple ways of knowing and solving problems (Tyagi, 2025; Sahu, 2025; Garcia-Olp et al., 2022; S & M, 2023; Sharma & Bakshi, 2025).

iv. **Emphasise sustainability-related tasks**: Data collection on local environmental issues (water, forests, waste), modelling resource use, or analysing community practices related to risk and resilience can link mathematics directly to SDGs (Gula & Jojo, 2024; Sahu, 2025; Demssie et al., 2020; Chen & Wu, 2024; S & M, 2023).

v. **Develop teacher education and research**: Long-term professional development and research on classroom implementation, including Indian case studies in rural and tribal schools, are crucial to move from theory to practice (Gula & Jojo, 2024; Tyagi, 2025; Sahu, 2025; Ogunniyi & Iwuanyanwu, 2024; Sharma & Bakshi, 2025).

CONCLUSION

Indigenous Mathematical Knowledge can make mathematics more inclusive, relevant, and contextually grounded in modern education. Recognising indigenous and Indian knowledge systems' rich mathematical practices might help education transcend beyond abstract and decontextualized approaches to improve conceptual understanding and learner engagement. The Capacity of IMK to connect mathematical learning to students' cultural backgrounds and living experiences promotes fairness and reduces learning hurdles, especially for rural learners. At the pedagogical level, the inclusion of IMK encourages the adoption of culturally responsive, experiential, and community-linked teaching practices. It calls for rethinking curriculum design, strengthening teacher preparedness, and ensuring that indigenous knowledge is represented authentically cum respectfully. Furthermore, IMK contributes significantly to sustainable perspectives by embedding ecological wisdom, ethical values, and resource-conscious practices within mathematics learning. Aligned with the vision of NEP 2020 and global goals such as SDG 4, the integration of IMK supports the development of not only mathematical competencies but also critical thinking, cultural awareness, and sustainability-oriented mindsets. Therefore, treating Indigenous Mathematical Knowledge as a dynamic and evolving resource can play a transformative role in shaping a more equitable, culturally rooted, and sustainable future of mathematics in the contemporary education System.

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