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Re-envisioning Mathematics Teacher Education through Indian Knowledge Systems: Perspectives from the National Curriculum Framework for Teacher Education and the National Education Policy 2020

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Abstract

The transformation of teacher education envisioned in the National Education Policy (NEP) 2020 has foregrounded the need for pedagogical approaches that are holistic, learner-centred, multidisciplinary, and deeply rooted in India's knowledge traditions. Within this policy landscape, the National Curriculum Framework for Teacher Education (NCFTE) seeks to prepare reflective practitioners capable of responding to evolving educational needs. Mathematics teacher education, however, continues to rely predominantly on procedural and decontextualized pedagogies. This conceptual paper argues that Indian Knowledge Systems (IKS) offer a meaningful pedagogical resource for re-envisioning mathematics teacher education. Drawing upon policy documents and scholarly literature, it examines the intersections between NEP 2020, NCFTE, and IKS and proposes that integrating Indian mathematical ideas and culturally situated learning experiences can strengthen conceptual understanding, inquiry-based learning, reflective practice, and pedagogical content knowledge among prospective teachers. The paper develops a conceptual framework for IKS-integrated mathematics teacher education that aligns policy aspirations with classroom practice while maintaining mathematical rigor. It concludes that meaningful integration of IKS can foster culturally responsive, contextually relevant, and intellectually rigorous mathematics teacher education.

Keywords: Indian Knowledge Systems, Mathematics Teacher Education, National Education Policy 2020, National Curriculum Framework for Teacher Education, Mathematics Pedagogy, Culturally Responsive Pedagogy, Teacher Education, Pedagogical Content Knowledge

Introduction

Education has long been regarded as the cornerstone of social transformation, economic progress, and cultural continuity. In the twenty-first century, the expectations from education have expanded considerably. Contemporary societies require learners who are capable not only of acquiring disciplinary knowledge but also of applying it creatively, solving complex problems, engaging in critical inquiry, and responding ethically to rapidly changing global realities. These changing expectations have reshaped the role of teachers, placing renewed emphasis on teacher education as the foundation for educational quality.

Among curricular domains, mathematics occupies a distinctive position because it cultivates logical reasoning, analytical thinking, abstraction, and problem-solving abilities. Consequently, the preparation of mathematics teachers demands pedagogical approaches that extend beyond procedural competence to include conceptual understanding, contextual sensitivity, reflective practice, and meaningful learner engagement.

Recognizing these imperatives, the National Education Policy (NEP) 2020 proposes a comprehensive transformation of the Indian education system by advocating learner-centred, multidisciplinary, competency-based, and experiential approaches to teaching and learning. One of its distinguishing features is the emphasis on reconnecting contemporary education with India's intellectual traditions through the meaningful integration of Indian Knowledge Systems (IKS). In alignment with this vision, the National Curriculum Framework for Teacher Education (NCFTE) seeks to redefine teacher preparation by emphasizing reflective professionalism, inclusive pedagogy, contextual learning, interdisciplinary perspectives, and continuous professional development.

Despite these progressive developments, mathematics teacher education in India continues to be influenced by instructional practices that privilege procedural fluency over conceptual reasoning and examination-oriented teaching over inquiry-based learning. India's rich mathematical heritage—including the Śulba Sūtras, Aryabhata, Brahmagupta, Bhāskara II, and Pingala—remains underutilized as a pedagogical resource. Rather than replacing contemporary mathematics, these traditions can enrich classroom pedagogy through culturally meaningful contexts, inquiry, visualization, and historical understanding. This paper argues that Indian Knowledge Systems should be viewed not merely as curriculum content but as a pedagogical lens through which future mathematics teachers can develop deeper conceptual understanding, culturally responsive teaching practices, and reflective professional identities.

Indian Knowledge Systems, National Education Policy 2020 and National Curriculum Framework for Teacher Education for Mathematics Education

The transformation of mathematics teacher education in India is closely aligned with the vision articulated in the National Education Policy (NEP) 2020 and the National Curriculum Framework for Teacher Education (NCFTE). Both documents advocate a shift from content-centered instruction towards learner-centered, inquiry-oriented, and competency-based teaching. Within this educational reform, Indian Knowledge Systems (IKS) emerge as a valuable pedagogical resource that can contextualize mathematical learning while preserving academic rigor.

Indian Knowledge Systems represent India's rich intellectual traditions encompassing philosophy, science, mathematics, astronomy, architecture, and other knowledge domains. In the Indian tradition, mathematics evolved through practical engagement with everyday life, including trade, architecture, astronomy, and measurement. Consequently, mathematical knowledge was not viewed as an isolated discipline but as an integral part of solving real-world problems. This perspective provides contemporary teacher education with opportunities to situate mathematical concepts within meaningful cultural and experiential contexts.

The National Education Policy (2020) reinforces this perspective by advocating experiential learning, critical thinking, multidisciplinary education, and the integration of Indian knowledge into curricula and pedagogy. Rather than treating IKS as historical content alone, the policy encourages educational institutions to utilize India's intellectual heritage to enrich classroom teaching and promote conceptual

understanding. For mathematics education, this implies creating learning experiences that connect abstract mathematical ideas with authentic cultural practices and historical developments.
Complementing this vision, the **National Curriculum Framework for Teacher Education** emphasizes preparing reflective professionals who possess strong pedagogical content knowledge, contextual understanding, and the ability to design meaningful learning experiences. Mathematics teachers are expected not only to demonstrate disciplinary competence but also to facilitate inquiry, reasoning, collaboration, and conceptual learning. These expectations resonate strongly with the pedagogical orientation embedded within Indian Knowledge Systems, where observation, dialogue, exploration, and experiential learning have traditionally played central roles. The convergence of IKS, NEP 2020, and NCFTE provides a strong foundation for re-envisioning mathematics teacher education. Together, they advocate a pedagogy that is culturally responsive, conceptually rich, and inquiry driven. Integrating Indian mathematical traditions—such as the geometric insights of the *Śulba Sūtras*, Aryabhata's computational methods, Brahmagupta's work on zero, and Bhāskara II's mathematical reasoning—can help prospective teachers appreciate mathematics as both a universal discipline and a product of human intellectual endeavour. Such integration encourages future teachers to move beyond procedural instruction and create classroom experiences that foster curiosity, critical thinking, and meaningful mathematical understanding. Viewed collectively, these policy initiatives do not advocate replacing contemporary mathematics with traditional knowledge. Rather, they encourage a thoughtful synthesis in which Indian Knowledge Systems serve as pedagogical resources for strengthening conceptual understanding and contextual relevance. This convergence establishes the foundation for developing an IKS-informed pedagogical framework for mathematics teacher education, which is discussed in the following section

Pedagogical Framework for Re-envisioning Mathematics Teacher Education through Indian Knowledge Systems

The pedagogical transformation envisaged by the NEP 2020 and the NCFTE requires mathematics teacher education to move beyond procedural instruction towards learner-centered, inquiry-oriented, and culturally responsive pedagogies. While contemporary theories of mathematics education have substantially enriched teaching practices, their application within Indian classrooms often remains detached from learners' socio-cultural experiences. Indian Knowledge Systems (IKS) provide an opportunity to bridge this disconnect by positioning mathematics not merely as an abstract discipline but as a living body of knowledge shaped by historical practices, local experiences, and indigenous ways of reasoning. Building on this premise, the present section proposes a pedagogical framework that integrates established educational theories with the philosophical foundations of IKS to strengthen mathematics teacher education.

Constructivist Foundations of Mathematics views learning as an active process through which learners construct mathematical understanding by connecting new ideas with prior experiences. Rather than transmitting ready-made knowledge, teachers facilitate environments where learners explore, question, and develop conceptual meaning through interaction and reflection. This perspective closely resonates with the epistemological foundations of Indian Knowledge Systems, where knowledge is acquired through observation (*pratyakṣa*), reasoning (*anumāna*), dialogue (*vāda*), and experiential engagement (*anubhava*). Such traditions emphasize understanding over memorization and encourage learners to investigate mathematical relationships within authentic contexts. For mathematics teacher education, a constructivist orientation implies preparing prospective teachers to design learning experiences that encourage inquiry, collaborative problem-solving and conceptual exploration. Integrating examples from indigenous architecture, traditional measurement systems, astronomical observations, and local mathematical practices enables learners to recognize mathematics as meaningful and culturally situated rather than as an isolated collection of rules and procedures. Consequently, constructivism and IKS converge in promoting classrooms where mathematical knowledge is actively constructed through contextual experiences.

Pedagogical Content Knowledge and Reflective Practice envisaged the effectiveness of mathematics teaching depends not only on disciplinary expertise but also on teachers' ability to transform mathematical knowledge into forms that are accessible and meaningful for learners. Shulman's concept of Pedagogical Content Knowledge (PCK) highlights this integration of subject matter knowledge, pedagogy, curriculum, and learners' understanding. Within the context of mathematics teacher education, PCK becomes particularly significant because abstract concepts often require multiple representations, contextual illustrations, and carefully sequenced instructional strategies. When viewed through the lens of Indian Knowledge Systems, Pedagogical Content Knowledge extends beyond selecting appropriate teaching methods. It encourages prospective teachers to draw upon culturally familiar contexts, indigenous mathematical practices, and locally relevant examples to facilitate conceptual understanding. Such integration strengthens learners' engagement while preserving mathematical rigour. Equally important is reflective practice, which enables teachers to critically examine their instructional decisions, classroom interactions, and students' learning processes. Reflection transforms teaching from a routine activity into a process of continuous professional inquiry, allowing mathematics teachers to refine pedagogical approaches in response to diverse classroom realities. Together, Pedagogical Content Knowledge and reflective practice cultivate adaptive, context-sensitive, and professionally competent mathematics teachers.

Culturally Responsive Mathematics Pedagogy recognizes learners' cultural backgrounds, languages, experiences, and community knowledge as valuable educational resources. Rather than treating culture as peripheral to mathematics learning, it positions cultural experiences as meaningful contexts through which mathematical concepts can be explored and understood. This perspective aligns closely with the objectives of NEP 2020, which advocates culturally rooted education while simultaneously promoting global competencies. Indian Knowledge Systems significantly enrich culturally responsive mathematics pedagogy by offering authentic examples from architecture, temple geometry, traditional commerce, agriculture, crafts, and indigenous technologies. These contexts enable prospective teachers to demonstrate that mathematical thinking has evolved through every day practices and intellectual traditions rather than exclusively through formal textbooks. Consequently, learners develop a stronger appreciation of mathematics as a dynamic and socially relevant discipline. Preparing teachers to integrate such culturally meaningful experiences contributes to inclusive classrooms where conceptual understanding, learner participation, and mathematical confidence are simultaneously enhanced.

Indian Knowledge Systems–Integrated Mathematics Teacher Education Framework (IKSMTE Framework)

Drawing upon the preceding pedagogical perspectives, this paper proposes the **Indian Knowledge Systems–Integrated Mathematics Teacher Education Framework (IKSMTE Framework)** as a conceptual model for re-envisioning mathematics teacher education. The framework positions Indian

Knowledge Systems not merely as additional curriculum content but as a pedagogical epistemology that informs the preparation of future mathematics teachers. It integrates constructivist learning, Pedagogical Content Knowledge, reflective practice, and culturally responsive pedagogy into a coherent model aligned with the vision of NEP 2020 and NCFTE. The framework conceptualizes mathematics teacher education through five interrelated dimensions: **epistemic foundations**, which recognize multiple ways of knowing and reasoning; **contextual pedagogy**, which situates mathematical learning within authentic cultural and community experiences; **pedagogical transformation**, which emphasizes inquiry, conceptual understanding, and learner participation; **reflective professional identity**, which encourages continuous pedagogical reflection and ethical practice; and **competency-based classroom practice**, which prepares teachers to facilitate meaningful, inclusive, and contextually relevant mathematics learning. These dimensions function synergistically to develop teachers who are mathematically competent, culturally responsive, and professionally reflective.

Unlike existing approaches that predominantly advocate the inclusion of Indian mathematical heritage as historical knowledge; the IKSMTE Framework proposes a systematic pedagogical integration of Indian Knowledge Systems within mathematics teacher education. In doing so, it offers a discipline-specific conceptual model capable of bridging the policy aspirations of NEP 2020 and NCFTE with classroom practice. The framework also establishes the foundation for examining the gaps in existing scholarship, discussed in the following section.

Figure 1: Indian Knowledge Systems–Integrated Mathematics Teacher Education Frame work (IKSMTE Framework)

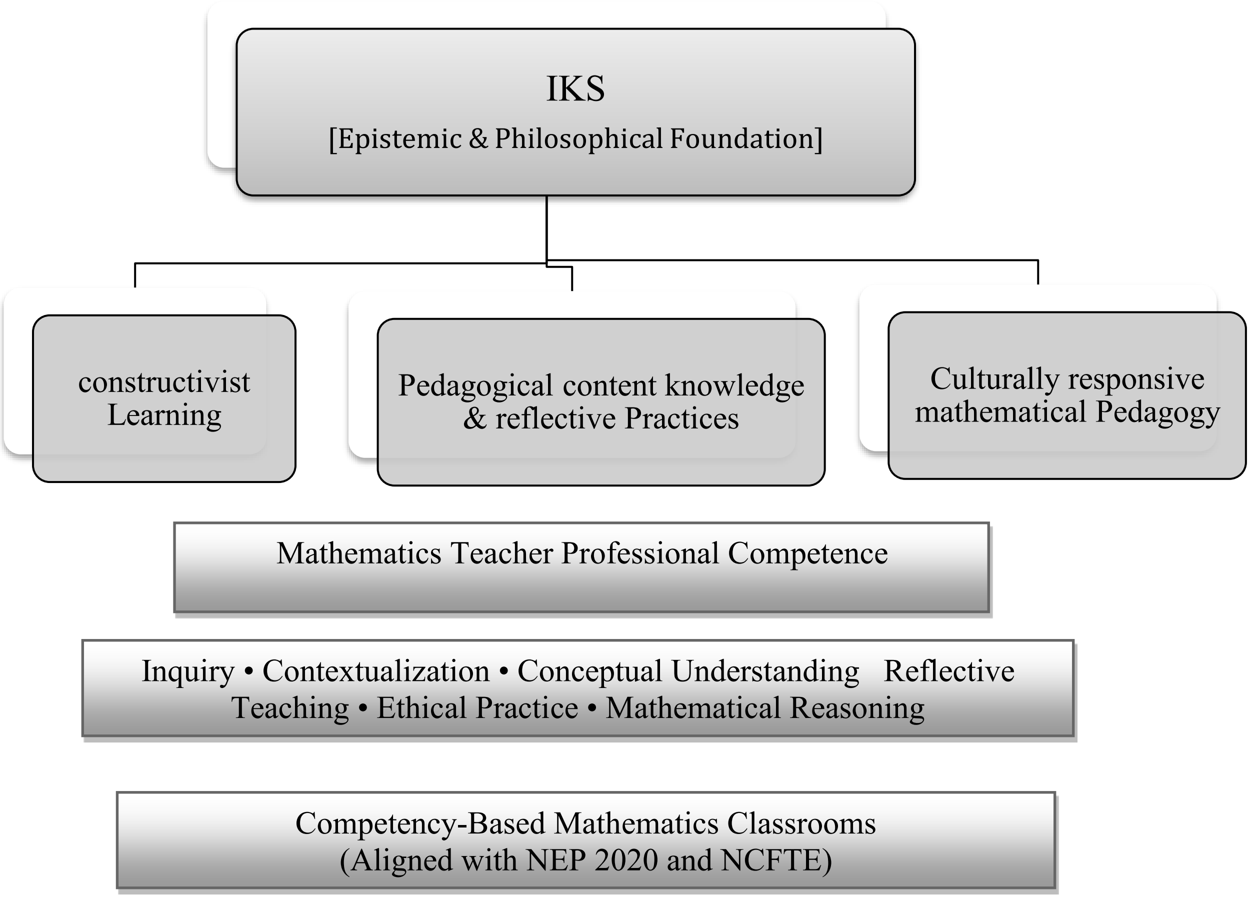

Figure 1. Proposed conceptual framework developed by the author.

Table 1: Alignment of IKS Principles with Mathematics Teacher Competencies

IKS Principle	Pedagogical Application in Mathematics	Mathematics Teacher Competency
Experiential Learning (*Anubhava*)	Activity-based and inquiry-oriented mathematics	Conceptual understanding
Observation and Reasoning (*Pratyakṣa–Anumāna*)	Mathematical investigation and problem-solving	Analytical reasoning
Contextual Knowledge	Indigenous practices, architecture, measurement, commerce	Contextualization of mathematics
Reflective Learning	Reflective journals, lesson analysis, peer dialogue	Reflective professional practice
Holistic Education	Collaborative and interdisciplinary learning	Inclusive classroom practices
Ethical Knowledge	Responsible and value-based teaching	Professional ethics and teacher identity

Table 1. Alignment of IKS Principles with Mathematics Teacher Competencies

Research Gap

The growing body of literature on Indian Knowledge Systems (IKS), mathematics education, and recent educational reforms has significantly enriched scholarly discourse on culturally rooted and competency-based education. Studies have documented India's rich mathematical heritage, analyzed the pedagogical implications of the National Education Policy (NEP) 2020, and examined emerging perspectives on teacher education. Nevertheless, a critical synthesis of this literature reveals that these three domains have largely evolved as parallel strands of inquiry, with limited attempts to integrate them into a coherent framework for mathematics teacher education.

The first gap is **conceptual**. Existing studies predominantly present IKS as historical knowledge or cultural heritage, highlighting the contributions of ancient Indian mathematicians and scientific traditions. While such scholarship is valuable in recognizing India's intellectual legacy, it seldom conceptualizes IKS as a pedagogical epistemology capable of shaping the teaching and learning of mathematics. Consequently, the transformative educational potential of IKS remains underexplored.

A second gap is **pedagogical**. Contemporary research frequently advocates learner-centred, experiential, and inquiry-based mathematics instruction; however, there is limited discussion on how indigenous mathematical practices, local knowledge systems, and culturally situated experiences can be systematically translated into mathematics teacher education programmes. As a result, prospective teachers receive minimal guidance on integrating IKS into classroom pedagogy without compromising mathematical rigor.

The third gap relates to the **policy–practice interface**. Although NEP 2020 and the National Curriculum Framework for Teacher Education strongly advocate contextual, multidisciplinary, and culturally responsive education, they provide broad policy directions rather than discipline-specific pedagogical models. Teacher education institutions therefore face considerable challenges in operationalising these policy aspirations within mathematics education.

Finally, a **framework gap** is evident in the literature. To date, no comprehensive conceptual model has been proposed that synthesises constructivist learning, pedagogical content knowledge, reflective practice, culturally responsive pedagogy, and Indian Knowledge Systems within the specific context of mathematics teacher education. The absence of such a discipline-specific framework limits both curriculum innovation and pedagogical transformation.

Addressing these interconnected gaps requires moving beyond the inclusion of IKS as supplementary curriculum content towards its integration as a pedagogical foundation for mathematics teacher education. In response, the present paper advances the **Indian Knowledge Systems–Integrated Mathematics Teacher Education Framework (IKSMTE Framework)** as a conceptual model that connects policy vision, educational theory, and classroom practice. The following section elaborates how this framework can re-envision mathematics teacher education in alignment with the aspirations of NEP 2020 and the National Curriculum Framework for Teacher Education.

Re-envisioning Mathematics Teacher Education through the Indian Knowledge Systems–Integrated Mathematics Teacher Education Framework (IKSMTE Framework)

The proposed **Indian Knowledge Systems–Integrated Mathematics Teacher Education Framework (IKSMTE Framework)** operationalised the pedagogical principles discussed in the preceding sections by demonstrating how Indian Knowledge Systems (IKS) can meaningfully transform mathematics teacher education. Rather than treating IKS as supplementary curricular content, the framework positions it as a pedagogical foundation that connects educational theory, cultural knowledge, and professional practice. Through epistemic reorientation, contextual pedagogy, reflective teaching, and competency-based preparation, the framework provides a discipline-specific approach for preparing mathematics teachers aligned with the vision of NEP 2020 and the National Curriculum Framework for Teacher Education.

Epistemic Reorientation of Mathematics Teacher Education

The IKSMTE Framework advocates an epistemic shift from viewing mathematics as a collection of abstract procedures to understanding it as a culturally and historically situated body of knowledge. Indian Knowledge Systems demonstrate that mathematical ideas have evolved through practical engagements in astronomy, architecture, commerce, agriculture, and everyday life. Integrating these perspectives enables prospective teachers to recognise multiple ways of constructing mathematical knowledge while maintaining conceptual rigour. Such an orientation encourages teachers to move beyond content transmission towards facilitating inquiry, reasoning, and conceptual understanding. Consequently, mathematics teacher education should provide opportunities for prospective teachers to critically examine mathematical knowledge from both contemporary and indigenous perspectives, thereby strengthening their professional identity and enriching classroom practice.

Contextualising Mathematics Learning through Indian Knowledge Systems

Meaningful mathematics learning occurs when concepts are connected with learners' experiences and cultural contexts. The IKSMTE Framework therefore encourages prospective teachers to utilise locally relevant examples such as traditional measurement systems, architectural designs, indigenous games, craft traditions, and commercial practices to illustrate mathematical concepts. These contexts function as pedagogical resources rather than historical anecdotes, enabling learners to explore patterns, relationships, and problem-solving strategies through authentic experiences. Preparing teachers to design such contextual learning experiences promotes culturally responsive classrooms where learners actively construct mathematical understanding. Contextualisation thus strengthens conceptual learning while making mathematics more relevant, inclusive, and socially meaningful.

Pedagogical Transformation for Conceptual Understanding

The IKSMTE Framework emphasises a shift from procedural instruction towards conceptual understanding through inquiry-based, experiential, and reflective pedagogies. Prospective teachers should be prepared to design learning experiences that encourage mathematical investigation, collaborative problem-solving, reflective questioning, and multiple representations of concepts. Indian Knowledge Systems enrich these pedagogical approaches by providing authentic contexts that stimulate reasoning and critical thinking. Teacher education programmes should therefore integrate reflective lesson planning, classroom inquiry, and collaborative professional learning into mathematics pedagogy. Such transformation prepares future teachers to facilitate intellectually rigorous, culturally responsive, and learner-centered mathematics classrooms that reflect the aspirations of NEP 2020 and NCFTE.

Developing Reflective and Culturally Responsive Mathematics Teachers

A key objective of the IKSMTE Framework is to prepare mathematics teachers who are both reflective practitioners and culturally responsive educators. Reflection enables teachers to critically examine their pedagogical decisions, classroom interactions, and learners' responses, thereby fostering continuous professional growth. Within the framework, reflective practice extends beyond self-evaluation to include an awareness of learners' cultural backgrounds, prior knowledge, and diverse ways of understanding mathematical concepts. Such an orientation aligns with the learner-centred philosophy advocated by NEP 2020 and reinforces the ethical responsibility of teachers to create inclusive learning environments.

Integrating Indian Knowledge Systems further enriches reflective practice by encouraging prospective teachers to appreciate indigenous mathematical ideas, local problem-solving traditions, and community knowledge as valuable pedagogical resources. Mathematics teacher education should therefore provide opportunities for reflective journals, peer discussions, classroom observations, and school-based internships that enable prospective teachers to connect theory with practice. Developing such reflective and culturally responsive professionals prepares teachers to facilitate mathematics learning that is intellectually rigorous, socially relevant, and responsive to the diversity of Indian classrooms.

Towards Competency-Based Mathematics Teacher Education

The successful implementation of the IKSMTE Framework ultimately depends upon preparing mathematics teachers who possess the professional competencies required for contemporary classrooms. Competency-based teacher education shifts the emphasis from acquiring theoretical knowledge to demonstrating the ability to apply mathematical understanding, pedagogical reasoning, contextual awareness, and reflective decision-making in authentic teaching situations. This perspective is consistent with the vision of NEP 2020 and NCFTE, which advocate preparing teachers capable of facilitating meaningful learning experiences rather than merely transmitting subject content.

Accordingly, mathematics teacher education programmes should redesign curriculum, practicum experiences, and assessment practices to incorporate inquiry-based lesson planning, contextual problem-solving, interdisciplinary projects, and reflective classroom engagement. Integrating Indian Knowledge Systems within these experiences enables prospective teachers to connect mathematical concepts with local contexts while promoting conceptual understanding, creativity, and critical thinking. Through this competency-oriented approach, the IKSMTE Framework prepares future mathematics teachers who are pedagogically competent, culturally responsive, and professionally reflective. Such preparation not only strengthens classroom practice but also contributes to achieving the broader educational goals of equity, quality, and holistic learning envisioned in contemporary teacher education reforms.

The proposed IKSMTE Framework presents a conceptual pathway for transforming mathematics teacher education through the meaningful integration of Indian Knowledge Systems. However, translating this framework into institutional practice requires addressing several structural, pedagogical, and professional challenges. The following section discusses these challenges and their implications for teacher education institutions, curriculum developers, and educational policymakers.

Challenges and Educational Implications

The successful implementation of the **Indian Knowledge Systems–Integrated Mathematics Teacher Education Framework (IKSMTE Framework)** requires coordinated efforts from teacher education institutions, policymakers, curriculum developers, and teacher educators. While the framework offers a conceptual pathway for strengthening mathematics teacher education, its implementation presents several challenges with important educational implications.

Challenges

- **Limited preparedness of teacher educators** to integrate Indian Knowledge Systems into mathematics pedagogy due to insufficient professional training.
- **Curriculum constraints**, where IKS is often presented as historical content rather than as a pedagogical approach.
- **Lack of quality teaching-learning resources**, contextual examples, and instructional materials that support IKS-based mathematics teaching.
- **Assessment practices** that continue to prioritise procedural knowledge over conceptual understanding, inquiry, and reflective learning.
- **Institutional resistance to pedagogical change**, limiting the adoption of interdisciplinary and culturally responsive teaching practices.

Educational Implications

- Teacher education programmes should redesign mathematics pedagogy courses to integrate the principles of the **IKSMTE Framework**.
- Continuous **faculty development programmes** are essential for strengthening teacher educators' understanding of IKS-informed pedagogy.
- Curriculum developers should incorporate **contextualised mathematical tasks, indigenous examples, and experiential learning opportunities** within teacher preparation.
- Assessment should emphasise **conceptual understanding, reflective practice, problem-solving, and competency-based learning**.
- Collaborative partnerships among **teacher education institutions, schools, and local communities** can promote meaningful integration of Indian Knowledge Systems into mathematics classrooms.

Addressing these challenges through systematic institutional reforms will enable the IKSMTE Framework to move beyond a conceptual model and become a practical approach for preparing reflective, culturally responsive, and professionally competent mathematics teachers in alignment with the aspirations of NEP 2020 and the National Curriculum Framework for Teacher Education.

Conclusion

The present paper contributes to the growing discourse on mathematics teacher education by moving beyond a policy-oriented interpretation of the National Education Policy (NEP) 2020 and the National Curriculum Framework for Teacher Education (NCFTE) towards a discipline-specific pedagogical perspective grounded in Indian Knowledge Systems (IKS). While existing scholarship has largely examined IKS, mathematics education, and teacher education as separate domains, this paper synthesises these perspectives through the proposed **Indian Knowledge Systems–Integrated Mathematics Teacher Education Framework (IKSMTE Framework)**. As its primary scholarly contribution, the framework conceptualises IKS not merely as historical or cultural content but as a pedagogical foundation that informs the preparation of reflective, culturally responsive, and competency-oriented mathematics teachers. By integrating constructivist learning, pedagogical content knowledge, reflective practice, and contextual pedagogy, the IKSMTE Framework offers a coherent approach for aligning mathematics teacher education with the transformative vision of NEP 2020 and NCFTE. Although its practical implementation requires institutional support and empirical validation, the framework provides a valuable conceptual foundation for future curriculum development, teacher education reforms, and research on culturally responsive mathematics education in India.

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