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Review Article

Indian Toy Research: Trends, Gaps and Future Directions

Rajesh P. Vansdadiya and Nimish H. Vasoya

Centre of Toy Science, Children's Research University, Gandhinagar, Gujarat, 382021, India

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Corresponding Author:
Nimish H. Vasoya
Centre of Toy Science, Children's Research University, Gandhinagar, Gujarat, 382021, India
Email: Nimishvasoya@yahoo.com

Abstract: This review aims to synthesize the current state of toy-related research in India, identify major research gaps, and propose a conceptual framework for the emerging interdisciplinary field of Toy Science. A structured review of approximately 95 India-focused publications was conducted. The reference list includes representative sources cited directly in the manuscript, while additional documents were used for thematic synthesis and evidence mapping. The reviewed literature was categorized into five thematic domains: Toy-based pedagogy, traditional toys and Indigenous Knowledge Systems, cognitive and motor development through play, STEM and digital toys, and toy safety and standards. The findings indicate growing evidence supporting toy-based learning, cultural preservation through traditional toys, and innovation through STEM initiatives such as Toycathon and Atal Tinkering Labs. Still, significant gaps remain, particularly in longitudinal research, interdisciplinary collaboration, toy safety surveillance, and evaluation of digital and technology-enabled toys. Based on the synthesis, a conceptual framework of Toy Science, a policy-evidence alignment matrix, and a national research roadmap are proposed. The study highlights the need for an integrated research ecosystem linking education, child development, design, engineering, culture, and policy to support evidence-based toy innovation and implementation aligned with the goals of the National Education Policy 2020.

Keywords: Toy-Based Learning, Indian Traditional Toys, STEM Education, Pedagogical Innovation, Toy Safety Standards, Atal Tinkering Labs, National Education Policy 2020

Introduction

Toys sit where culture meets learning and technology. Across India, you will find clay figures or painted wood pieces alongside robot sets and digital helpers utilizing augmented reality (Ministry of Education, 2022) (Vansdadiya and Vasoya, 2022). By approximately 2020, new policies, including an early education program plan and the NEP 2020, began promoting more hands-on, playful learning experiential techniques and away from rote learning (Ministry of Education, 2020). This change in focus has brought about a renewed interest among teachers concerning what toys are capable of teaching (Mishra, 2023).

The national initiatives, such as Toycathon and support of innovative projects, have brought up a few new ideas and numerous new products to be used in schools, factories, and local toy producers (Ministry of Electronics and Information Technology, 2025). Toycathon was an unprecedented partnership involving six Indian government ministries and departments that was based on crowdsourcing to generate new ideas for the toy industry in India (Invest, 2021). The initiative was also designed to strengthen India's domestic toy ecosystem and reduce dependence on imported toys (Press Information Bureau, 2021).

However, despite the ongoing policy initiatives, university research on toys in India remains fragmented, appearing in streams like teaching methods, mind studies, material technology, or handmade crafts -but often limited in scope and disciplinary coverage (Mishra, 2023).

The conceptual foundations of Toy Science draw from multiple theoretical traditions. Constructivist theory proposes that children actively construct knowledge through interaction with objects and environments (Piaget, 1972). Sociocultural theory emphasizes the role of social interaction, cultural tools, and guided participation in learning (Vygotsky, 1978). Experiential learning theory highlights learning through direct experience and reflection (Kolb, 1984), while embodied cognition suggests that physical manipulation of objects contributes to conceptual understanding (Wilson, 2002). Together, these perspectives provide a theoretical basis

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for understanding toys not merely as play objects but as learning tools that support cognitive, social, emotional, and creative development.

In this review, Toy Science is defined as an interdisciplinary field that examines the design, development, educational application, cultural significance, safety, materials, policy environment, and societal impact of toys. Different educational psychology, which primarily focuses on learning processes or materials science, which focuses on physical properties and manufacturing (Rangaswamy et al., 2018), Toy Science integrates these perspectives to understand toys as educational, cultural, technological, and developmental systems. The field, therefore, serves as a bridge connecting child development, pedagogy, design, engineering, indigenous knowledge systems, public policy, and industry.

Materials and Methods

This study adopts a narrative review and policy-integrated analytical approach to synthesize Indian research on toys and play-based learning. A narrative method was selected instead of a systematic meta-analysis due to the heterogeneity of study designs, disciplines, and publication formats in Indian toy-related research and the significant presence of grey literature such as government reports, policy documents, doctoral theses, and programme evaluations.

Review Design

This study adopts a structured narrative review informed by scoping review principles. A fully systematic review was not feasible because toy-related research in India is highly heterogeneous and includes peer-reviewed articles, doctoral theses, policy documents, programme reports, government publications, and institutional evaluations. Therefore, a structured evidence-mapping approach was employed to identify research trends, thematic patterns, knowledge gaps, and future research priorities. The review process was guided by key elements of the PRISMA-ScR framework to improve methodological transparency and reproducibility.

Data Sources and Search Strategy

Literature published between 2000 and 2025 was identified from multiple academic and policy-oriented sources, including Google Scholar, Scopus, INFLIBNET Shodhganga (INFLIBNET Centre, 2024), ResearchGate, and official government portals.

Search terms included combinations of:

"Toy-based learning India", "traditional toys India", "STEM toys", "play-based pedagogy", "toy safety standards India", "Atal Tinkering Labs", "Channapatna toys", and "Indian toy industry".

The search strategy employed Boolean operators to improve retrieval precision and coverage across databases. Representative search strings included:

("Toy-based learning" OR "play-based learning") AND India
("Traditional toys" OR "indigenous toys") AND India
("STEM toys" OR robotics OR digital toys) AND India
("Toy safety" OR toy standards OR BIS standards) AND India
("Play-based pedagogy" AND India) OR ("experiential learning" AND toys)

These search strings were adapted as required for different databases and repositories.

Inclusion and Exclusion Criteria

Included sources met the following criteria:

- Focused on India-specific contexts
- Addressed toys, play, pedagogy, child development, materials, safety, or toy-related policy
- Published as peer-reviewed articles, theses, government reports, or formal evaluations

Excluded Sources:

- Studies not relevant to the Indian context
- Opinion pieces without methodological transparency
- Commercial blogs without verifiable data sources

Approximately 95 Relevant Documents Were Shortlisted and Thematically Analyzed.

Figure 1 recaps the document selection process used in this review. Literature was acknowledged from various academic databases, institutional repositories, policy portals, and government sources. Following screening for relevance and application of inclusion and exclusion criteria, approximately 95 documents were retained for thematic combination and evidence mapping.

Data Analysis and Synthesis

Selected literature was categorized into five thematic domains:

(1) Toy-based pedagogy
(2) Traditional toys and Indigenous Knowledge Systems
(3) Cognitive and motor development
(4) STEM and digital toys and
(5) toy safety, materials, and standards

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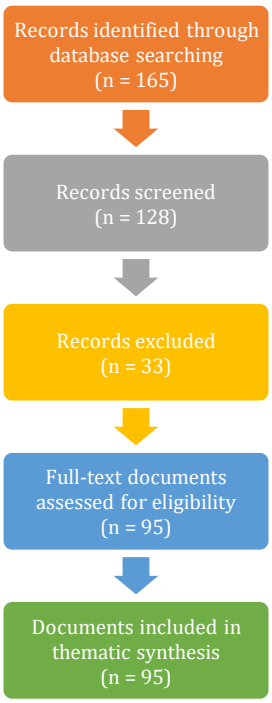

Fig. 1: PRISMA-style flow diagram illustrating identification, screening, eligibility assessment, and inclusion of documents in the review

An integrative conceptual framework of Toy Science was developed to synthesise findings across domains and guide interpretation.

To synthesize the diverse components of the literature reviewed in this study, a conceptual framework of Toy Science was developed (Figure 2). The framework positions Toy Science as an interdisciplinary ecosystem integrating pedagogy, child development, indigenous knowledge systems, STEM innovation, materials, safety research, and teacher training within a broader policy and governance context. The framework served as a guide to organize and analyze the research data, which will be presented in the following sections.

Table 1 summarizes the distribution of the 95 documents reviewed across the five major thematic domains identified in this study. Toy-based pedagogy constituted the largest body of literature, reflecting growing interest in play-based and experiential learning approaches within Indian education. STEM and digital toys represented the second-largest category, largely driven by recent policy initiatives such as Atal Tinkering Labs and Toycathon. In contrast, toy safety, materials research, and cognitive development studies remain comparatively underrepresented. The findings indicate a significant imbalance in the current evidence base and highlight the need for greater research attention toward safety, longitudinal learning outcomes, and interdisciplinary evaluation of emerging toy technologies.

Figure 2 illustrates a game-based learning framework highlighting the interactions among game types, emotional dimensions, technological applications, and analytical approaches. The figure demonstrates how educational games combine cognitive, emotional, and technological elements to support learning outcomes. Since game-based learning represents one component of the broader Toy Science ecosystem, the framework provides useful insights into the educational mechanisms through which toys and games facilitate engagement and learning.

Although Figure 2 focuses specifically on game-based learning, it represents one educational subsystem within the broader Toy Science framework proposed in this study, illustrating how toys and games support learning through interactions among cognitive, emotional, and technological dimensions.

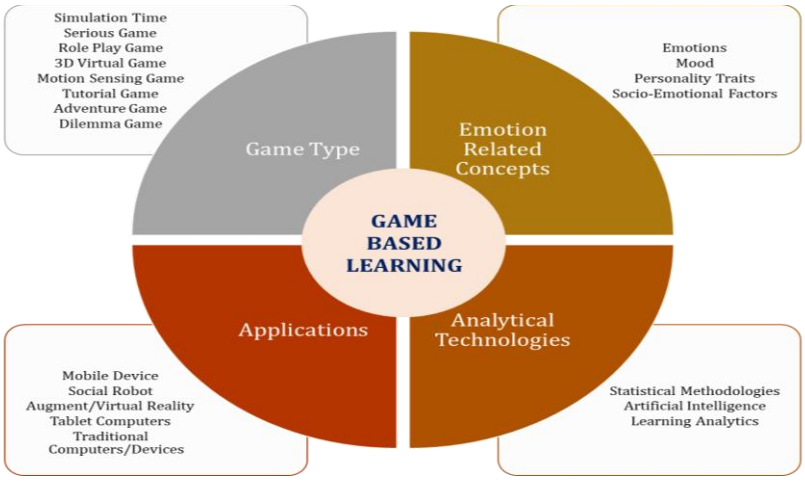

Fig. 2: Game-based learning framework showing relationships among game types, emotional dimensions, applications, and analytical technologies in educational environments

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Table 1: Summary of the reviewed literature on Indian toy research (N = 95 documents)

Domain	Documents Reviewed	Key Findings	Major Gaps
Toy-Based Pedagogy	28	Improved engagement and learning	Few longitudinal studies
Traditional Toys	18	Cultural preservation	Limited educational evaluation
Cognitive Development	14	Motor and cognitive benefits	Small sample sizes
STEM and Digital Toys	20	Innovation and creativity	Limited effectiveness studies
Toy Safety	15	Compliance concerns	Lack of surveillance research

Results

Toy-Based Pedagogy and Classroom Learning

The most extensive collection of Indian studies concerns toys and practical tools to teach young children simple mathematical and scientific concepts. Projects that use counting sets, tangrams, or Jodo Gyan kits often demonstrate better conceptual understanding, heightened interest, and more energetic classroom participation (State Education Mission Authority Meghalaya, 2016). The Jodo Gyan programme records show that when teachers implement kit-based approaches, teaching quality improves substantially if proper training and ongoing support are provided (Gyan, 2020).

The Jodo Gyan intervention in Meghalaya witnessed significant outcomes, with the Joint Review Mission noting that children responded to teachers with considerable enthusiasm during mathematics lessons and that the materials and kits on mathematical concepts proved extremely interesting whilst stimulating curiosity amongst pupils (State Education Mission Authority Meghalaya, 2016).

Children demonstrated visible improvement in counting and number writing through the introduction of hands-on activities, and teachers provided favorable feedback that these activities enabled them to identify children's learning difficulties more readily (Vasoya et al., 2023; State Education Mission Authority Meghalaya, 2016). Although these initiatives demonstrate promising outcomes, their limited duration and restricted implementation contexts make it difficult to determine whether the observed improvements can be sustained over time.

The National Curriculum Framework for Early Years, along with the National Education Policy 2020, reflects the official support of the playful learning approach (Ministry of Education, 2022). In this respect, the pedagogical approach of toy-based learning is found to corroborate these policies as it develops the motor skills and emotional growth of children while teaching them about national cultural heritage (Ministry of Education, 2022; Mishra, 2023; Vansdadiya and Gondaliya, 2024). The research findings show that toy-based pedagogy stands as one of the most evidence-based fields in Indian toy research, but the available evidence focuses on brief periods within particular settings. Similar recommendations have been highlighted by recent early childhood education reforms that advocate experiential and play-based approaches to foundational learning (Central Square Foundation, 2024).

Traditional Toys and Indigenous Knowledge Systems

Traditional toy-making clusters such as Channapatna (Karnataka) and Kondapalli (Andhra Pradesh) represent important repositories of indigenous knowledge, craftsmanship, and cultural heritage. Existing studies highlight their contribution to sustainable production practices, local livelihoods, and the preservation of regional identity. Traditional toys also embody locally developed knowledge regarding materials, aesthetics, storytelling, and child engagement. However, most available studies focus on cultural documentation and artisan livelihoods rather than empirical evaluation of educational outcomes. Consequently, stronger interdisciplinary research is required to examine how traditional toys can be integrated into contemporary pedagogical frameworks while simultaneously supporting cultural sustainability and artisan economies.

Traditional toys embody indigenous knowledge related to materials, design, storytelling, and child engagement. Beyond their cultural significance, these toys offer opportunities for integrating local knowledge systems into contemporary educational practice (Vignan University, 2024). However, empirical evidence examining their pedagogical effectiveness remains limited. Future research should investigate how traditional toys can support curriculum objectives while simultaneously preserving cultural heritage and strengthening artisan livelihoods. Studies of folk toys further suggest that traditional play objects communicate social values, symbolic meanings, and community identity across generations (Chakraborty, 2023).

Although the relevance of traditional toys is high in terms of culture and sustainability, the current research on traditional toys is more qualitative and poorly connected with the evaluation of the learning outcome.

Cognitive and Motor Development Through Play

Play-based activities within Indian classrooms for young children seem to gear them up with improved fine motor control, spatial awareness, memory retention, and sustained focus for the attainment of objectives. Games like Ludo or chess, both at home and in a tournament, help children to plan their strategies better, take turns, and solve problems whenever they are challenged. Engaging in drawing, crafts, and sensory activities such as play-dough enhances children's fine motor abilities. Outdoor activities such as obstacle courses and dancing improve

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the development of gross motor abilities in children (Ginsburg, 2007).

Many studies rely on convenience sampling, limiting the generalizability of findings across diverse populations. Which means non-random sample selection and the measurements tools in them are often not robust and developed directly for measuring cognitive skills. Therefore, it is not always appropriate to generalize those results to a larger, flexible set of population groups (Arya and Patel, 2023).

Through play-based learning, cognition can be developed by using two types of activities that include puzzles and building blocks. The latter also provides children with such skills as problem-solving, attention, cause-and-effect relations, and focusing on improving memory and attention.

Indian classroom-based studies using puzzles, construction blocks, manipulative mathematics kits, and traditional board games have reported improvements in problem-solving ability, attention span, hand–eye coordination, and collaborative learning. Evaluations associated with Jodo Gyan mathematics programs and activity-based learning initiatives further suggest that structured play interventions contribute positively to cognitive engagement and concept formation among primary school children. Still, large-scale longitudinal evidence remains limited.

STEM, Robotics, and Digital Toys

The people and institutions are increasingly playing with STEM toys, robotic kits, and do-it-yourself learning environments, especially through the Atal Tinkering Labs. A nationwide overview demonstrates that over 10,000 Atal Tinkering Labs have been established across India; in locations where they receive adequate support, children exhibit heightened curiosity toward science and demonstrate stronger capacity for addressing real-world challenges independently (Atal Innovation Mission, 2024). Through these laboratories, more than 1.1 crore (11 million) students have formed over 16 lakh (1.6 million) innovative projects, with more than 400 patents filed and 2,727 start-ups established (Journal of Emerging Technologies and Innovative Research, 2024). The government's ambitious initiative entails the establishment of 50,000 Atal Tinkering Labs in government schools during the next five years. This is a significant advancement in making STEM education accessible across India, including both urban and rural areas (Vansdadiya et al., 2023; Atal Innovation Mission, 2024).

Nevertheless, it shows little evidence of measurable learning gains, and even where it does, it is not always in learners in Classes 6 -12, but not necessarily in younger learners. These projects actually work well, depending on execution at the state level and acceptance in schools, as many states are fast adopting digital STEM tools, and others face difficulties due to financial limits or capacity to adopt. The innovation potential of STEM toy initiatives is high; however, little evidence exists that STEM toys can produce a lasting learning effect, particularly in younger students.

Toy Safety, Materials, and Standards

Although the toy industry in India is rapidly developing as the market, not many studies have been carried out with regards to the question of toy safety. Whilst the Bureau of Indian Standards has issued standards and guidance including the IS 9873 set covering mechanical, flammability and safety aspects and IS 15644 for electronic toys actual testing to verify product compliance is exceptionally limited (Bureau of Indian Standards, 2025). The Quality Control Order for Toys 2020 mandates compliance, yet enforcement and autonomous confirmation persist in varying.

Empirical data regarding contamination from hazardous substances such as heavy metals or phthalates is virtually absent in India-specific literature. The Centre for Science and Environment's 2013 study revealed phthalates exceeding internationally accepted safe limits in 45 per cent of toys tested, whilst a subsequent Indian Council of Medical Research study commissioned by the Supreme Court identified phthalates above prescribed thresholds in 32.6 per cent of toys in some instances up to ten times the permitted limit.

A recent study carried out by the Quality Council of India in 2019 discovered that 30 percent of plastic toys and 45 percent of soft toys did not comply with safety standards for phthalates, and that about 67 percent of the imported toys (from China) were not of quality.

The documentation regarding child injuries resulting from defective toys has remained very limited, if not non-existent. The lack of data concerning the whole situation has significantly hampered the process of establishing confidence in play learning tools, as well as the expansion of the potential associated with the toy industry within the Indian environment.

Teacher Training and Implementation Challenges

Educators generally express positive attitudes toward toy-based pedagogy; however, implementation remains constrained by several structural barriers. Common challenges include inadequate professional development opportunities, limited access to locally relevant learning materials, curriculum alignment concerns, and time constraints within formal classroom schedules. Evidence from multiple states suggests that successful implementation depends heavily on sustained teacher training, institutional support, and the availability of quality educational resources.

Recent initiatives aligned with the National Curriculum Framework for the Foundational Stage have emphasized capacity-building for early childhood educators through structured professional development programmes. Nevertheless, substantial variation exists across states with respect to funding, infrastructure, availability of trained personnel, and coordination among educational agencies. These disparities highlight the need for a more systematic and nationally coordinated strategy for teacher preparation in toy-based learning.

To prepare teachers with the principles and methodologies of toy-based pedagogy (Amuthavalli and Srisaila, 2025), Kendriya Vidyalaya Sangathan (KVS) has created extensive teacher training programmes to realize that successful implementation requires educator preparedness (Kendriya Vidyalaya Sangathan Regional Office Kolkata, 2019). Nevertheless, standardization of teacher training and the availability of sources in different physical and socioeconomic systems is a contest that is yet to be resolved.

Critical Gaps and Limitations in Indian Toy Research

Fragmentation and Lack of Interdisciplinary Work

Research related to toys in India remains highly fragmented across disciplinary boundaries. Educational specialists focus on how children acquire knowledge and skills; toy historians document ancient games and traditional crafts; whilst engineers and designers concentrate on model construction and innovation (National Institute of Design, n.d.). However, the information on child development models seldom intersects with material science research or practical design experimentation frameworks, so there is no synergy between these two intellectual spheres (Mishra, 2023). This does not help in interdisciplinary collaboration and, thus, does not give comprehensive information regarding the intersection of toy design, material properties, and pedagogical effectiveness to help with the total child development (The Pharma Journal, 2023).

The handbook on toy-based pedagogy published by the National Centre of Educational Research and Training is one of the rare attempts at closing these gaps by tracing various toys, especially the indigenous collection in India, through developmental processes (National Council of Educational Research and Training, 2022). Yet most research endeavors remain siloed within individual academic disciplines, preventing the emergence of an integrated knowledge ecosystem.

Small-Scale, Short-Term Evaluations

Numerous investigations suffer from severely constrained scope and duration. Brief pilot interventions and limited-sample studies complicate the ability to substantiate assertions regarding sustained outcomes or scalable systems that can be replicated across diverse educational contexts. According to a scoping review of educational research in India spanning 2006 to 2015, whilst scholarly productivity increased from 3 per cent to 44 per cent during this period, approximately 80 per cent of these studies targeted undergraduate populations, emphasizing single-site quantitative surveys and stakeholder perceptions rather than outcome-oriented evaluations.

The emphasis on convenience sampling selecting readily accessible participant groups rather than employing random selection or representative sampling techniques further undermines the generalizability of findings (Arya and Patel, 2023). Furthermore, resource-intensive longitudinal research proficient in following sustained behavioral change and evolving outcomes remains remarkably rare due to insufficient funding and the absence of dedicated institutional infrastructure for long-term educational research.

Limited Research on Safety, Materials, and Market Compliance

While toy safety has received increased policy attention in recent years, empirical evidence regarding compliance, market surveillance, chemical contamination, and injury reporting remains limited. Existing studies suggest important safety concerns, but efficient and nationally representative investigations remain rare. This gap highlights the need for comprehensive monitoring systems and independent safety evaluation mechanisms.

There is practically no literature that documents pediatric injuries that can be specifically linked to faulty toys. Such an important knowledge gap is a substantial impediment to the formulation of evidence-based safety frameworks and creates a difficulty in the capacity to establish stakeholder trust in toy-centered learning and play-based educational strategies. Moreover, the systematic market surveillance that monitors the continuous observance of manufacturers to BIS standards is not advanced and thus allows products that do not meet the standard to enter the market periodically.

Insufficient Evaluation of Digital and Technology-Enabled Toys

Rigorous comparative research studies comparing high-end digital tools, e.g., coding robots, virtual reality applications, and adaptive learning platforms with traditional hands-on materials are also conspicuously limited (Merchant et al., 2014). Although technology-based toy programmes are actively spreading to Indian schools and educational institutions, there is little direct

empirical evidence on the direct comparison of learning effectiveness, engagement, growth, and cost-benefit studies.

Edu robots demonstrate the possibility of increasing STEM abilities, problem-solving, and team learning. Studies have demonstrated that robots stimulate interest and inspiration among students and understanding of mathematical and engineering concepts, particularly when paired with effective training of educators (Benitti, 2012). The VR applications in early childhood demonstrate that one can increase creative potential and cognitive growth and address the problems by utilizing the concept of an immersive, gamified world.

Nonetheless, they are still marked by a number of serious gaps. The high-technology intervention is not compared with the traditional pedagogical technique in terms of using simple materials at a sufficient level in order to define whether the technology investment in terms of high costs can provide more effective learning results than the alternatives with lower costs (Benitti, 2012). Research of the British Council regarding technology implementation in Indian schools demonstrates certain outcomes that tablets and other online platforms produced measurable results in terms of the increase of core academic skills by 11 percent, but bigger systemic studies involving the different population groups in digital and traditional strategies are slight (Council, 2025).

Specifically, data on efficacy disaggregated according to socioeconomic contexts, regional context, and demographics of learners is constrained. With artificial intelligence, augmented reality, and coding-based learning tools in the toy market increasingly becoming part of the 2025 market trend of STEM toys and toys that integrate technology, there is no comprehensive comparative research, which will facilitate decision-making on policymaking and resource allocation.

Poor Reporting of Regional Toy Diversity and Economies

There is still scanty and disjointed empirical research recording the economic, educational, and cultural aspects of the regional toy-making practices in India. Whilst Channapatna in Karnataka and Kondapalli in Andhra Pradesh represent iconic centers of traditional toy-making heritage, scholarship integrating artisan survival, income sustainability, pedagogical value, and cultural preservation remains underdeveloped.

While traditional toy-making clusters such as Channapatna and Kondapalli have received increasing scholarly and policy attention, existing research remains fragmented and largely descriptive. Most studies focus on cultural preservation, artisan livelihoods, and heritage documentation, while limited empirical evidence exists regarding educational effectiveness, learning outcomes, market sustainability, and policy impacts. Consequently, stronger interdisciplinary research is needed to examine how traditional toy ecosystems contribute simultaneously to education, cultural continuity, local economic development, and sustainable innovation.

Limited studies give a systematic analysis of the relationships that exist between artisan earnings, pedagogical efficacy of conventional toys, heritage conservation, market accessibility, and policy assistance. The documentation of Kondapalli toy-makers by the Sustainable Playthings Research Foundation shows the fall of informal economies, but does not provide detailed data on educational outcomes, measurements of cultural impact, or potential preservation measures on a scale (SPRF India, 2022).

National initiatives including the Channapatna Crafts Park (established a decade ago), Lepakshi's artisan empowerment programmes, and government-sponsored toy clusters provide support through training, infrastructure access, and design innovation (Mongabay, 2024). Nevertheless, systematic research documenting whether these interventions sustain traditional toy-making whilst simultaneously enhancing educational value remains absent. The absence of integrated research examining artisan economics, toy-based learning efficacy, cultural preservation objectives, and market sustainability represents a critical research lacuna that prevents a holistic understanding of how traditional toy-making can simultaneously serve educational, economic, and cultural functions across diverse Indian regions.

According to the Ministry of Commerce and Industry (2024), the Indian toy industry remains highly fragmented, with a substantial proportion of production contributed by Micro, Small, and Medium Enterprises (MSMEs) operating in the unorganized sector. Evidence-based policies to facilitate sustainable livelihoods of artisans and, at the same time, use traditional toys as educational aids are hard to find without rigorous and interdisciplinary research that embraces these dimensions. The major limitations and evidence gaps identified across the reviewed literature were synthesized into a Research Gap and Priority Matrix (Figure 3). The matrix was developed by categorizing the five thematic domains according to two dimensions:

(i) Research maturity, reflecting the volume and methodological strength of existing studies
(ii) Policy and societal impact, reflecting their relevance to educational practice, child development, industry, and national policy priorities. This framework provides a strategic tool for identifying areas requiring immediate research attention and future investment

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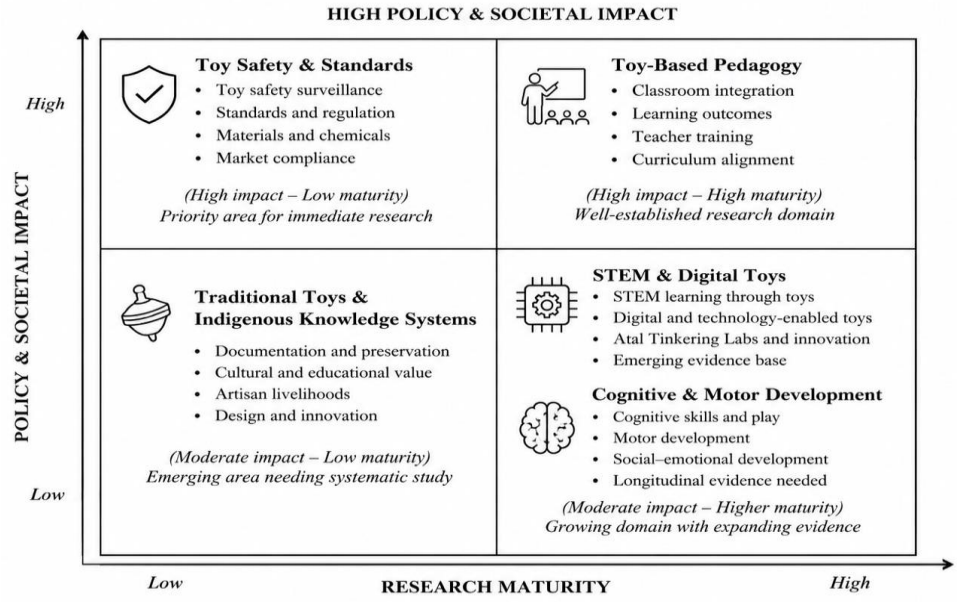

Fig. 3: Research Gap and Priority Matrix for Indian Toy Research derived from the review of 95 India-focused publications

The positioning of thematic domains within Figure 3 was determined through qualitative synthesis of the reviewed literature based on the maturity of existing research and its perceived educational, societal, and policy relevance.

Figure 3 maps the major domains of Indian toy research according to their current level of research maturity and policy or societal significance. Toy Safety and Standards occupy the high-impact but low-maturity quadrant, indicating a critical need for systematic research on safety surveillance, materials testing, regulatory compliance, and injury reporting. Traditional Toys and Indigenous Knowledge Systems also demonstrate substantial cultural and educational importance but remain underrepresented in empirical research.

Toy-Based Pedagogy appears in the high-impact and high-maturity quadrant, reflecting the relatively strong evidence base supporting play-based learning, classroom implementation, and teacher training initiatives. STEM and Digital Toys, together with Cognitive and Motor Development research, occupy the emerging-growth quadrant, where increasing evidence exists, but further longitudinal and comparative studies are required. The matrix provides a strategic roadmap for researchers, policymakers, funding agencies, and educational institutions seeking to strengthen the emerging field of Toy Science in India.

Discussion

Implications for Research

Toys traditional or modern enhance cognitive, motor, and emotional learning when implemented by trained educators. NEP 2020 and NCF-FS explicitly endorse play-based methodologies, whilst Toycathon and 10,000+ Atal Tinkering Labs demonstrate government commitment to innovation. However, converting policy into scalable impact requires interdisciplinary research hubs integrating pedagogy, child psychology, materials science, ergonomics, and design as exemplified by Lady Irwin College's HDCS department and IIM Ahmedabad's Ravi J Matthai Centre.

Figure 4 demonstrates that policy attention is strongest in toy-based pedagogy and foundational learning. In contrast, digital toys, toy safety, and materials research receive substantial policy attention but comparatively weaker empirical support.

This Matrix shows the relationship between the Toy-Related Fields and the amount of empirical evidence that supports them, and the amount of attention Policymakers in India give to them. The Matrix also indicates that there is a strong correlation between Empirical Research Support and Policy Focus on Toy-Based Pedagogy, Play for Young Children, etc., while Digital Toys and Material Science Research Areas have a high level of relevance to policy, but have little empirical evidence to support them, which means they require immediate attention and empirical study. This Matrix can identify areas where policymakers' decisions may be supported with empirical research and strategically fund research related to the implementation of the National Education Policy (NEP) 2020 and/or other national policies.

The major gaps identified in Table 1 including limited longitudinal research, inadequate evaluation of traditional toys, small sample sizes in developmental studies, insufficient effectiveness research on STEM toys, and

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weak safety surveillance systems remain priority areas for future investigation.

Implications for Policy and Governance

Priority actions include: Longitudinal randomized studies tracking sustained outcomes; BIS safety testing expansion (IS 9873 compliance at 98% for tested products) with phthalate/heavy metal research; comprehensive teacher training via NCERT frameworks; digital twins preserving Channapatna/Kondapalli toys through 3D scanning for AR/VR classrooms; and sustainable materials development. Policymakers must fund hubs and enforcement; researchers co-design with artisans using mixed methods; industry leverages Toycathon/ATLs for prototypes; teacher educators embed toys in NCF-FS/NEP training. This establishes "toy science" as a national priority.

Implications for Practice and Industry

Based on the identified research gaps and policy–evidence alignment, a phased national roadmap is proposed to guide the development of Toy Science in India over the next five to ten years (Figure 5). The roadmap summarizes a phased strategy for establishing, scaling, and global positioning of Toy Science in India. Horizon 1 (Years 1–3) focuses on building foundational research infrastructure, longitudinal studies, and toy safety surveillance systems. Horizon 2 (Years 3–6) emphasises scaling validated models through interdisciplinary research grants, industry–academia consortia, and digital–IKS hybrid toy development. Horizon 3 (Years 7–10) targets global leadership through national data portals, regulatory benchmarking, and international standard alignment, positioning India as a leader in sustainable and culturally grounded toy innovation.

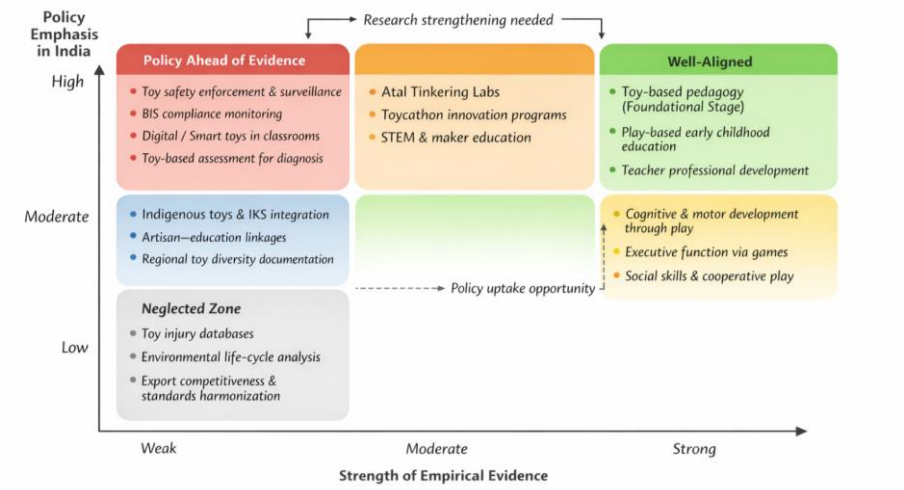

Fig. 4: Policy evidence alignment matrix for toy-related research in India

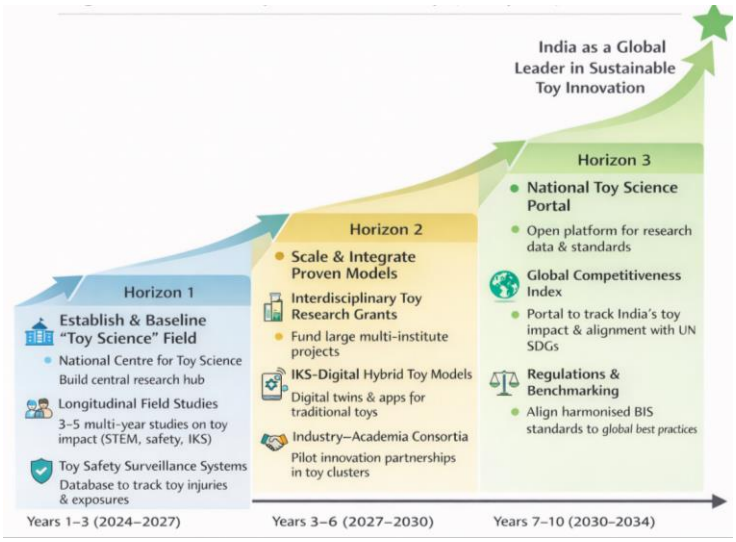

Fig. 5: National Toy Science roadmap (5–10 years)

Conclusion

This review demonstrates that research related to toys in India has expanded significantly during the past two decades, but remains fragmented across educational, psychological, cultural, technological, and industrial domains. The synthesis reveals strong evidence supporting toy-based pedagogy and increasing policy support through initiatives such as NEP 2020, Toycathon, and Atal Tinkering Labs. However, important gaps persist in longitudinal evaluation, toy safety research, interdisciplinary collaboration, and assessment of digital toys. The proposed Toy Science framework offers a foundation for integrating these diverse research streams into a coherent field of inquiry. Future research should prioritize methodological precision, cross-disciplinary collaboration, and evidence-based policy development to strengthen the educational, cultural, and economic contributions of toys in India.

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Author's Contributions

Rajesh P. Vansdadiya: Contributed to the literature collection, results, and initial drafted.

Nimish H. Vasoya: Conceptualized the study, developed the analytical framework, guided policy interpretation, and finalized the manuscript.

Both authors reviewed and approved the final version of the manuscript.

Ethics

This study is a review of published literature and policy documents and did not involve human participants, animal subjects, or primary data collection. Therefore, ethical approval was not required.

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